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Design of an In-core Fission Spectrum Neutron Irradiation Facility with Pneumatic Sample Transfer at a Research Reactor

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Design of an In-core Fission Spectrum Neutron Irradiation Facility with Pneumatic Sample Transfer at a Research Reactor

by

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Dedication

I would like to dedicate this work to my cats: Daenerys and Sansa. Both of you have been there for me since the start of college, keeping me grounded each step of the way. You both may not live forever, but perhaps this work will keep your memory alive. And to my partner, Violet Rose Cantu, for enduring my late nights and early days spent working towards this degree and those that preceded this. I am grateful for the love and support you've given every step of the way.

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Abstract

Design of an In-core Fission Spectrum Neutron Irradiation Facility with Pneumatic Sample Transfer at a Research Reactor

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The University of Texas at Austin, 2019

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The objective of this thesis was to provide instruction on the design, optimization and construction of a fast neutron irradiation facility with pneumatic sample transfer at the Nuclear Engineering Teaching Lab (NETL) reactor core. This facility will be used for fast neutron activation analysis and fast neutron fission in uranium and plutonium samples. Various materials and geometric designs were researched and modeled in Monte Carlo Neutral Particle (MCNP) code for the filtration of thermal neutrons from the NETL reactor core. The approach to these models were described as well as the subsequent processes in yielding the finalized design. The model geometry was recreated in SCALE to provide estimations for expected fission product activities. The design that was built was based off a layered cylindrical format that was placed inside a modified 3-element (EL) container. This container was created to fit into the 3-EL irradiation position of the core. The design balances the need to maintain high total neutron flux with the careful shaping of a neutron spectrum to be as close to the Watt fission spectrum as possible. The models indicated that the thermal+epithermal neutron flux was reduced by five orders of magnitude while

leaving the fast neutron flux virtually untouched. That value was tallied after the reactor core flux is shaped by the neutron absorbing materials. The fast:(thermal+epithermal) flux ratio should exceed 100:1 with an integrated fast flux value (defined > 0.001 MeV) of at least 7.8×10^{11} n cm^{-2} s^{-1}. The calculated activity from the irradiation of 10 mg Pu via SCALE was determined to be 94.97 MBq.

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INTRODUCTION

A Brief Overview

The science and engineering in this work detail the shaping of the TRIGA Mark-II research reactor neutron flux to resemble the ^{235}U Watt fission spectrum. This spectrum is representative of what neutron energies a ^{235}U atom would see in the detonation of a nuclear weapon. The purpose of this work falls in an important component of post-detonation, nuclear forensics research where there is a demand in decreasing the statistical uncertainties of short-lived fission product branching ratios, half-lives, yields, etc. The research in this thesis will address other facilities that aimed to achieve a similar neutron spectrum. It will also cover where this facility excels and comes short in achieving the desired fission spectrum.

Note, the ^{235}U Watt fission-spectrum is made of up fast neutrons with average energy ~2 MeV. To achieve a similar spectrum with a TRIGA research reactor, the thermal and epithermal neutrons in the flux of the reactor core must be removed. Therefore, cadmium metal and boron powder, 97% enriched ^{10}B, were utilized. These materials were used to shape the starting neutron flux spectrum by removing virtually all thermal and epithermal neutrons. The materials were structured inside a 3-element (EL) irradiation insert. This was modelled in its corresponding irradiation position in the reactor core where flux (F4) tallies and fission product activities were calculated using MCNP and SCALE, respectively. The heating in the facility was jointly computed through use of MCNP (F6) tallies and SolidWorks Flow Simulation. The design of this facility includes schematics on a pneumatic transfer system which will allow for sample transfer to and from the reactor core. Lastly, the 3-EL neutron flux distribution (in the z-axis) was experimentally characterized using an Al-wire stretched across the length of a Pb-lined 3-EL insert.

History of Neutrons in the Field of Nuclear Engineering

Neutrons are perhaps the most important aspect of nuclear engineering. Without them the field would probably cease to exist. They are of little interest in most scientific fields that are not nuclear related. There are generally only two facts that are learned about them: they are neutral in charge and coexist in the nucleus of an atom with protons. The education on how neutrons act as a glue inside the nucleus in order to keep protons from repelling one another is typically reserved for more specialized fields like particle physics or astrophysics. Without neutrons, the formation of the elements and their respective isotopes aside from the most basic of all, hydrogen, would not be possible. In contrast, neutrons are not able to survive long outside the nucleus. They are a radioactive species when not bound with a half-life of 10.3 minutes (Lamarsh & Baratta, 2001).

The discovery of neutrons occurred in 1932 by James Chadwick (Rogers, 2013) where he utilized a scattering experiment to calculate the mass of the neutral particle. Not too long after that discovery, artificial nuclear chain reactions were created by Enrico Fermi in 1934 (Guerra, Leone, & Robotti, 2006). Resulting from that idea came the well-known, “Fermi-pile” in 1942 as a part of the Manhattan Project. The Manhattan Project served as the codename for the research and development of novel science during World War II. This project eventually led to the development of the first nuclear bomb. The Fermi pile became the first self-sustaining nuclear chain reaction and is credited towards the making of the atomic bombs that ended World War II. The basic science behind neutron-induced chain reactions can be explained by the graphic on the following page. A free neutron collides with the nucleus of a fissionable nuclide and causes it to break apart. This typically results in two new nuclei called fission products. The splitting of the nuclide also results in the emission of two to three neutrons. The neutrons then go on to cause more fissions and create a chain reaction. The use of neutrons to cause fissions result in a massive amount of energy produced per unit mass.

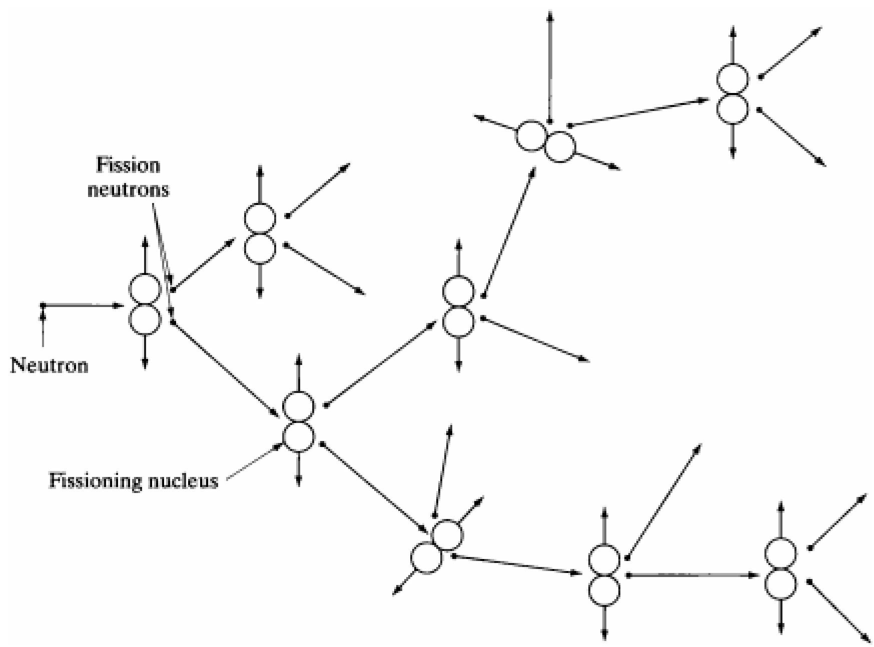

Figure 1: Schematic of a fission chain reaction (Lamarsh & Baratta, 2001).

When a chain reaction is made supercritical, ie: for every neutron that causes a fission more neutrons are produced than consumed in the system, a massive amount of energy is produced in a very short time interval. Often this cannot be controlled, and the buildup of energy increases exponentially. This is ideal for nuclear weapons. For a chain reaction that is critical, ie: the number of neutrons that are produced from fission and consumed from fission are kept equal, the energy produced from fission can be controlled. This means that energy can be extracted over a reasonable amount of time. This is usually by means of heating water to produce steam, which is fed into a turbine, creating electricity (the typical Rankine cycle). That is the basic science of how nuclear power plants produce energy. A nuclear reactor is not restricted to applications in the energy sector. It can also be adapted to be useful in the scientific world. Research reactors, like the TRIGA Mark II located at the University of Texas at Austin, can be used to perform a wide range of experiments on samples through a variety of irradiation facilities.

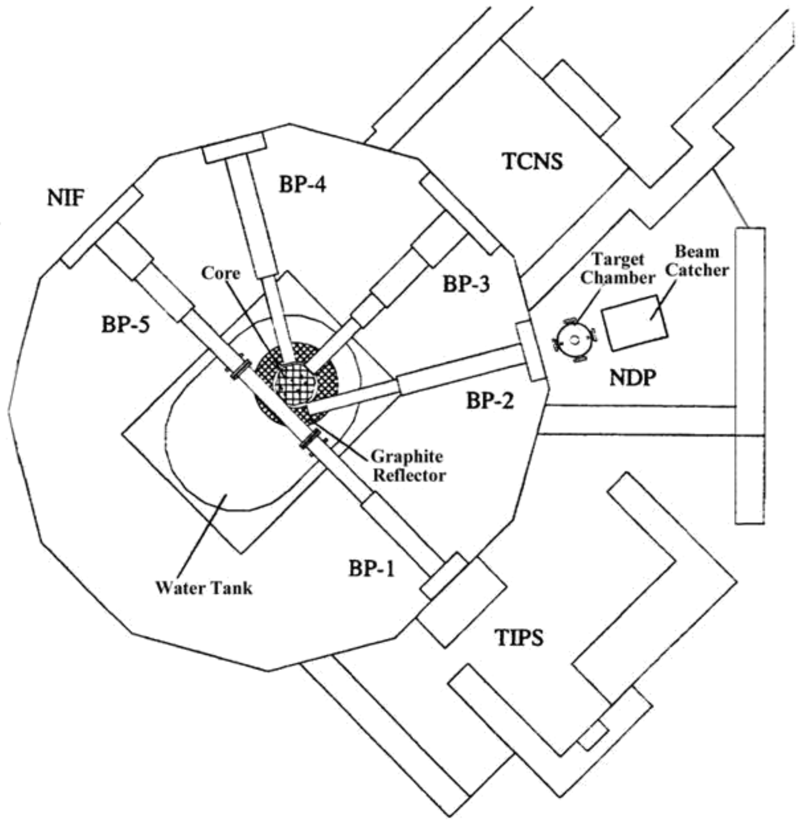

Figure 2: Schematic of the facilities located throughout the TRIGA Mark II.

The Figure above shows the various ways in which the research reactor can and has been used. There are five separate beam ports that allow irradiations of samples external to the reactor core. In addition, samples can also be irradiated inside the core of the research reactor either through a rotary rack, manual insertion or through uses of a pneumatic system into a semi-permanent facility. The work of this thesis will focus on an in-core irradiation facility.

NEUTRONS

Neutron Physics

In a nuclear reactor, neutrons are freed from the nucleus of an atom through neutron-induced fission reactions. The neutrons that occupy a nuclear reactor can span a range of energies from 10^{-11} MeV to 25 MeV. These neutrons are often described by their kinetic energy or velocity, as the equation for kinetic energy shows:

$$\mathrm{KE} = \frac{1}{2}\mathrm{mv}^2 \tag{1}$$

where KE is the kinetic energy (J), m is the mass of the neutron (kg) and v is its velocity (m s^{-1}). Using the formula for the kinetic energy of free gas, it becomes obvious that the kinetic energy may also be described by units of temperature, rather than velocity:

$$\mathrm{KE} = \frac{3}{2}k_B T \tag{2}$$

where k_B is Boltzmann's constant (J/K) and T is the temperature (K) of the system. Equation (1) shows that the velocity of the neutron is directly related to the kinetic energy. The following equation reveals a relationship between velocity and temperature through the equality of kinetic energy. The velocity or kinetic energy of a neutron is often described in terms of its temperature. This would require the treatment of a system of neutrons as free gas particles. The temperature of a system of neutrons can be described by their kinetic energy. After substitution for the Maxwellian distribution for free gas and a little algebra, the can be portrayed by the Maxwellian distribution for neutron thermalization (Lamarsh, 2005):

$$n(E)dE = \frac{2n_{th}}{\sqrt{\pi}kT} \cdot \sqrt{\frac{E}{kT}} \cdot e^{-\frac{E}{kT}}dE \tag{3}$$

where n(E)dE is the number of neutrons per unit volume having energy in the range between E and E + dE, n_{th} is the total density of thermalized neutrons, k is Boltzmann's constant, T is the temperature thermal neutrons and E is their kinetic energy. Although it is well known that the above distribution requires modification to fully describe the relationship across all neutron energies (not just thermal), the relationship between a neutrons kinetic energy and temperature point remains valid.

Table 1: Range of neutron energies with respect to various parameters.

Term	Energy	Velocity (m/s)	Wavelength (nm)	Temperature (K)
ultracold	$<0.2\ \mu$eV	<6	>64	<0.002
very cold	$0.2\ \mu\text{eV} \leq E < 50\ \mu\text{eV}$	$6 \leq v < 100$	$4 < \lambda \leq 64$	$0.002 \leq T < 0.6$
cold	$0.05\ \text{meV} < E \leq 25\ \text{meV}$	$100 < v \leq 2200$	$0.18 \leq \lambda < 4$	$0.6 < T \leq 300$
thermal	25 meV	2200	0.18	300
epithermal	$25\ \text{meV} < E \leq 500\ \text{keV}$	$2200 < v \leq 1 \times 10^7$		
fast	>500 keV	$>1 \times 10^7$		

Each term of Table 1 describes regions in the neutron energy spectrum that yield differing probabilities for numerous types of nuclear reactions to take place. The likelihood of a specific nuclear reaction occurring is consequently dependent on the composition and properties of the material that the neutron is incident on. This includes the physical properties like the temperature and density of the material. Neutrons are typically restricted to interactions with the nuclei of materials because the probability of neutrons interacting with charged species like an electron or free proton is extremely low. Therefore neutrons are restricted to only being capable of interacting with the nuclei of atoms (Lamarsh & Baratta, 2001). Neutrons are also capable of interacting with one another (Lamarsh, 2005). But due to the large distances that exist between individual neutrons in a neutron population (ie: low density), they are often more likely to interact with their surrounding medium than each other. Therefore, their behavior is usually modelled as an average composite of the total neutron fluence in a system, as the neutron transport equation is based on. This can be thought of to be scientifically analogous to the Debye-Huckel Theory describing the departure from ideality in solutions of electrolytes (Gabler, 2012). At extremely low concentrations or densities, the way in which the colligative properties of an electrolytic species in its environment departs from is proportional to the concentration of the solute. Thus, the activity coefficients of the ions in the solutions was developed where the mean activity coefficient was used to predict the behavior of the dilute ions in solutions. The interaction of a neutron with a target nucleus could be in a billiard ball style (elastic) collision where the neutron bounces off the nucleus, imparting all, some or none of its energy in the form of kinetic energy. The neutron can also be temporarily absorbed by the target nucleus upon interaction. This could result in the subsequent emission of the neutron where some of its energy is imparted into the energy state of the target nucleus itself (inelastic collision). The neutron can also remain absorbed in the nucleus and any initial energy of the neutron is the converted to binding and excitation energy onto the nucleus. Generally, the type of reaction that occurs is also dependent on the probabilities and nuclear stabilities of the target nuclei rather than just the collision of the neutron with the nuclei. This leads the discussion towards the next topic: neutron cross sections.

Cross Sections

Neutron cross sections detail the probability that a specific particle reaction will occur. There are two types of cross-sections that are used in nuclear engineering: the microscopic cross section, σ, and the macroscopic cross section, Σ, where the latter is defined as:

$$\Sigma = \sigma N \tag{4}$$

The atom density, N, has units of atoms cm^{-3} and σ has units of cm^2. The microscopic cross section is more frequently reported in barns or b which is equivalent to 10^{-24} cm^2. The macroscopic cross-section is defined as the probability per unit path length that a particle will undergo an interaction with a specific material, defined by the microscopic cross section. The microscopic cross section is defined as a probabilistic area about a nucleus in which a nuclear interaction is likely to occur. This is dependent on the neutron's incident energy as well as the excitation of the nucleus itself. The nuclear interactions presented on the following page show three main branches of nuclear cross sections: scattering, absorption, and transfer.

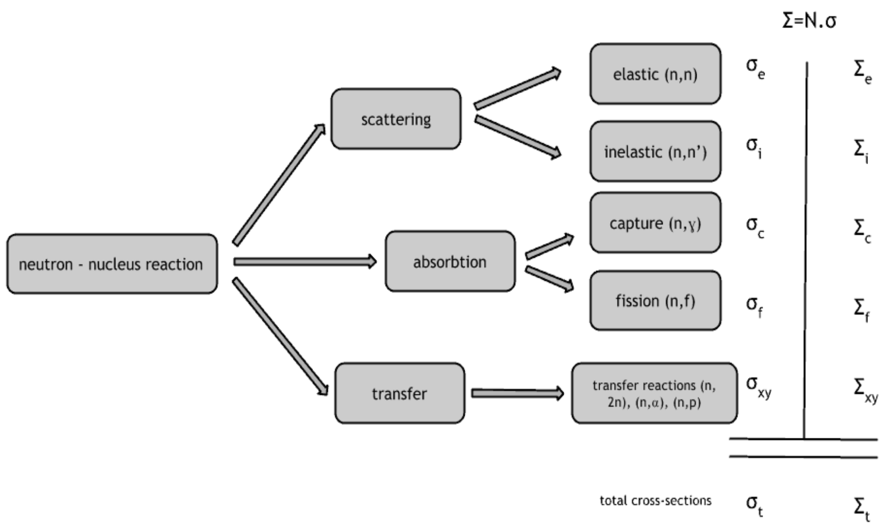

Figure 3: Shows the many interactions a neutron may undergo with a target nucleus.

The total cross section is composed of three groups in which neutron interactions are organized in:

$$\sigma_{\text{total}} = \sigma_{scattering} + \sigma_{absorption} + \sigma_{transfer} \quad (5)$$

The scattering cross sections encompass reactions that are the most physical, meaning, they can be represented by examples such as the classical billiard ball style interaction. The incident neutron goes in and comes out. This neutron will either have the same (elastic) or less (inelastic) energy.

$$\sigma_{\text{scattering}} = \sigma_{elastic} + \sigma_{inelastic} \quad (6)$$

The absorption branch can be thought of as the total loss of the neutron in the reaction as it is radiatively captured or results in the atom fissioning. These types of reactions often result in the emission of secondary radiation such as γ-rays, neutrons, α-particles and fission products.

$$\sigma_{\text{absorption}} = \sigma_{capture} + \sigma_{fission} \quad (7)$$

The transfer branch is composed of all the other types of nuclear reactions where a single neutron results in the emission of 2 neutrons, an α-particle, a proton, a deuteron, etc.

$$\sigma_{\text{transfer}} = \sigma_{n,2n} + \sigma_{n,3n} + \sigma_{n,\alpha} + \sigma_{n,t} + \sigma_{n,d} + \sigma_{n,p} + etc \ \ldots \qquad (8)$$

For the focus of this thesis, two specific cross sections were valued above all others. The first of those cross sections was the (n,α) cross section of ^{10}B. The second was the (n,γ) cross section of ^{113}Cd.

Boron consists of two stable isotopes that exist in nature, ^{10}B (20%) and ^{11}B (80%). There happens to be a large variation in the total neutron cross sections between these two nuclei. These differences are due to the nuclear stabilities and preferences that each nucleus may have. When the ^{10}B atom interacts with and absorbs a neutron, for example, it is more favorable that that atom, now an excited ^{11}B* atom, splits into a ^{7}Li ion and an α-particle. This is because of the excess energy acquired during the nuclear reaction which was enough to make the splitting more favorable than remaining as a ^{11}B atom.

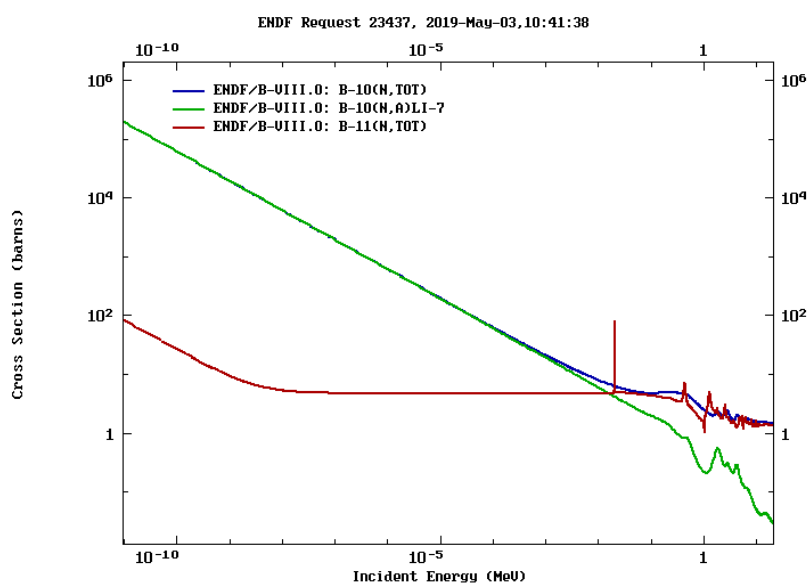

Figure 4: Comparison of the total cross sections of ^{10}B and ^{11}B; comparison of the (n,tot) and (n,α) reaction of ^{10}B (Brown et al., 2018).

The difference between the cross sections of ^{10}B and ^{11}B at low neutron energies are seen in Figure 4. The goal of this work was to utilize materials with large thermal neutron cross-sections to create a fast neutron spectrum from a predominantly thermal neutron spectrum. The cross section of ^{10}B is dominated by the (n,α) reaction as opposed to the typical (n,γ) reactions. Figure 4 illustrates this discrepancy in thought that a ^{10}B atom would much rather proceed to splitting into two particles, an α-particle and ^{7}Li, than stay as ^{11}B, despite the stability of ^{11}B as an isotope of boron. This is noted to be a common trait in lighter elements as they are frequently utilized for their production of charged particles in neutron depth profiling (Downing, Lamaze, Langland, & Hwang, 2012). The charged particle emissions from the ^{10}B capture reaction will be discussed in further detail in the following sections, shedding light on the resulting heat generation and helium production. Heat is generated because the daughter products are heavy and charged, therefore, all their energy is deposited locally. Helium gas is generated from the same daughter products after an α-particle regains two electrons, since it is initially doubly ionized.

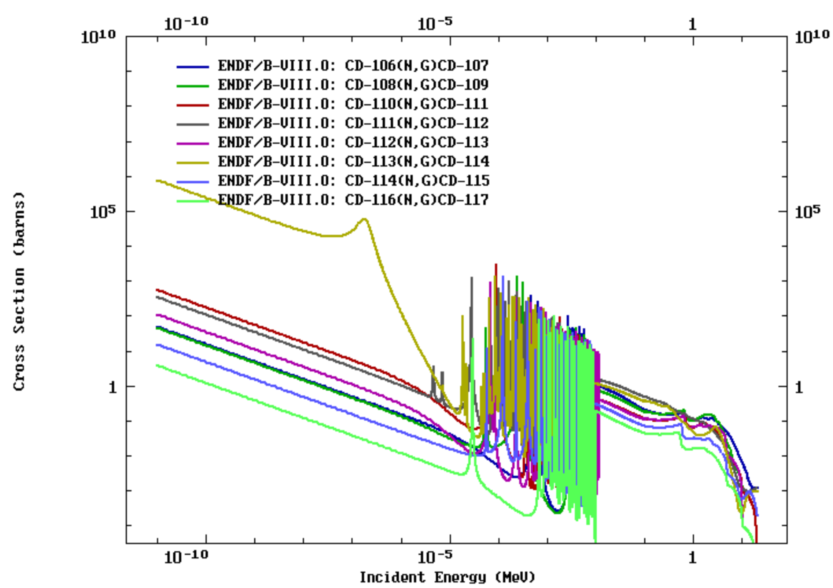

Figure 5: Comparison of (n,γ) cross sections of the naturally occurring isotopes of Cd (Brown et al., 2018).

Following the trend denoted by boron and its isotopes comes cadmium and its isotopes of interest: ^{106}Cd (1.25%), ^{108}Cd (0.89%), ^{110}Cd (12.49%), ^{111}Cd (12.80%), ^{112}Cd (24.13%), ^{113}Cd (12.22%), ^{114}Cd (28.73%), and ^{116}Cd (7.49%). The (n,γ) cross sections of these are shown in Figure 5 above. The only useful isotope in absorbing thermal neutrons is ^{113}Cd which only constitutes 12.22% of the total isotopic abundance. On a similar note, recall that ^{10}B exists in nature as only 20% of the total isotopic abundance. The significance of the small percentage of ^{113}Cd is vital as it is less in isotopic density compared to the total mass density of the material; such is the same with ^{10}B. The enrichment of isotopes is common practice, as an enriched form of boron powder was used in this work to attain a larger density of the isotope ^{10}B. The enrichment of Cd metal is less common and necessary because of the already substantial density of the metal itself (8.65 g cm^{-3}).

Gadolinium (Gd) is also a highly competent absorber of thermal-epithermal neutrons. The naturally occurring isotopic composition of this element is: ^{154}Gd (2.18%), ^{155}Gd (14.80%), ^{156}Gd (20.47%), ^{157}Gd (15.65%), ^{158}Gd (24.84%) and ^{160}Gd (21.86%). The (n,γ) cross sections of these isotopes can be found on the following page.

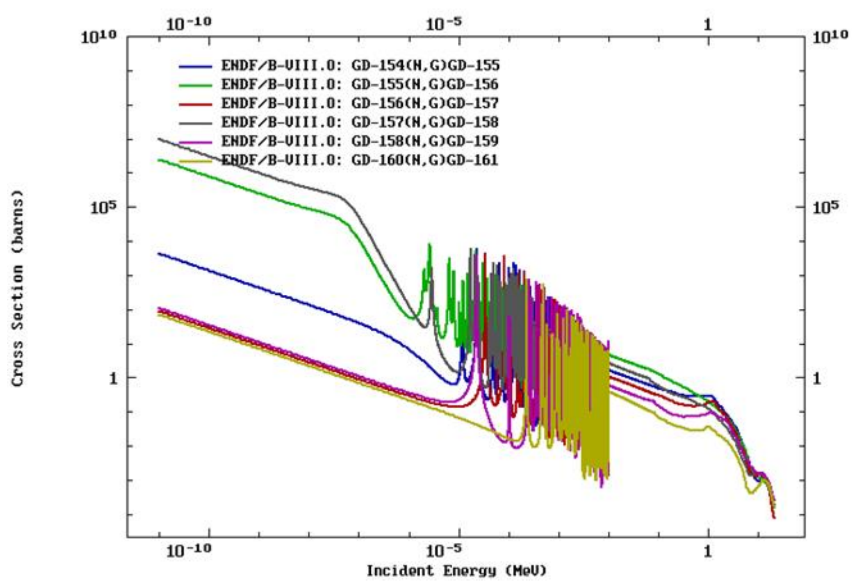

Figure 6: Comparison of (n,γ) cross sections of the naturally occurring isotopes of Gd (Brown et al., 2018).

With a density of 7.90 g cm^{-3}, this material was briefly looked at to be a contender to cadmium since it is nearly twice as effective as cadmium in terms of absorption of thermal neutrons per unit volume due to ^{155}Gd & ^{157}Gd (cumulative 30.45%). But since it costs more and becomes more activated than cadmium, it was dismissed in this design but may be used in future endeavors.

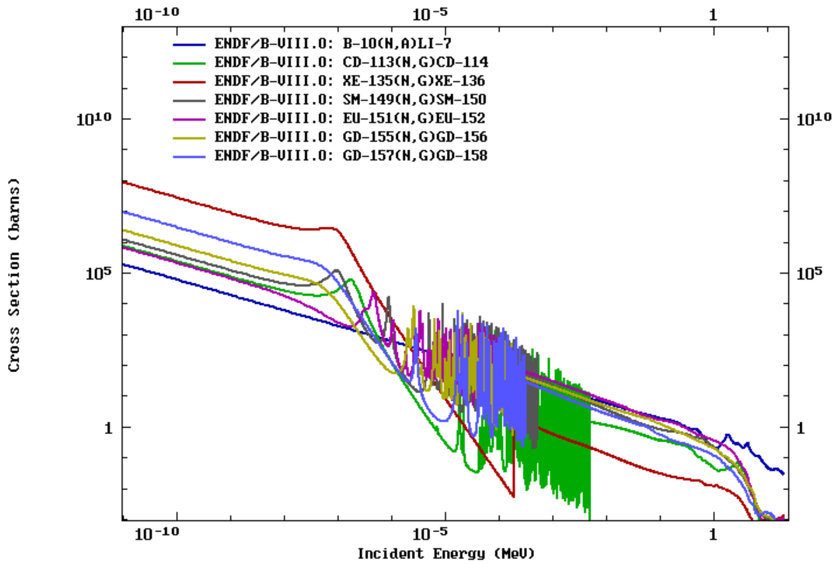

Figure 7: Neutron capture cross sections of various neutron absorbers (Brown et al., 2018).

Other competent thermal/epithermal neutron absorbers exist in the nuclear engineering world. The main neutron absorbers of interest can be reduced to the following six nuclides: ^{10}B, ^{113}Cd, ^{149}Sm, ^{151}Eu, ^{155}Gd and ^{157}Gd (King & El-Genk, 2006). Europium, Eu, has been utilized in the oxide form to absorb thermal and epithermal neutrons in order to create a fast neutron spectrum (Gehin, Ellis, Mcduffee, Hobbs, & Snead, 2008; Mcduffee et al., 2008). Samarium, Sm, is a well-known fission product that, if not given consideration to its buildup and decay during operation and shutdown of a nuclear reactor, could lead to an event similar to that of Chernobyl. Xenon, Xe, like Sm, is a fission product (^{135}Xe) that must be taken into consideration. However, because of its noble gas properties, it cannot practically be used as a material for thermal neutron absorption (likely the reason it was not mentioned in (King & El-Genk, 2006)).

Neutron Activation Analysis

Neutron activation analysis (NAA) can be understood as the bombardment of neutrons upon a sample from a neutron source (such as a research reactor) such that the atoms become activated. Upon activation, the nuclide may either form another stable nuclide or form a radioactive species. In either case, a prompt emission of energy is bound to occur. Then comes the delayed emission of energies which encompasses the radioactive species decay at their respective half-lives. These emit radiation that can therefore be

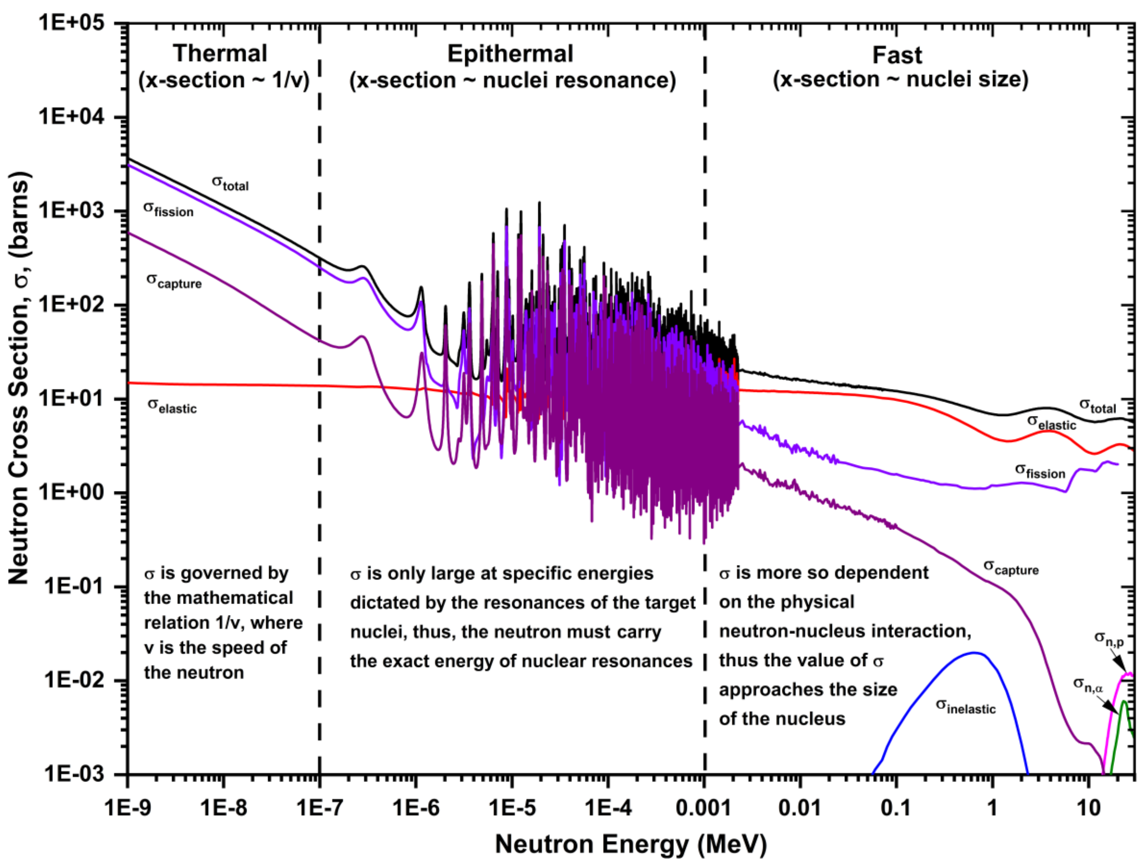

Figure 8: Regions of neutron activation analysis.

detected. Figure 8 displays the general regions of neutron activation analysis as it pertains to the cross sections of a ^{235}U atom being subject to an arbitrary neutron flux.

The NAA method covers a wide range of irradiation energies (0.025 eV to 14 MeV) which allow for multiple applications. The most frequent application is trace elemental determinations in materials of unknown composition. As an example, this can involve the provenance of ancient Egyptian pottery. In epithermal NAA, thermal neutrons are filtered out of the reactor spectrum using neutron absorbing materials, i.e. materials with high thermal neutron absorption cross sections. For this type of NAA, cadmium is the standard neutron absorbing material because the neutron absorption cross section for ^{113}Cd is, at 0.0253 eV, 20,673 barns and larger at lower energies (encroaching the cold and ultra-cold regions) while it has an immediate drop in absorption starting at about 0.4 eV. This type of NAA is useful for the activation of isotopes whose epithermal cross sections are more comparable to competing isotopes in the sample media whose thermal cross sections are much larger.

To provide an alternative route, (Bem & Ryan, 1981) explored the advantages of using various boron compounds in the form of powders to try and improve sensitivities of various epithermal reactions that otherwise could not be achieved with just a cadmium shield. Much like those powders explored in this thesis, the powders (Bem & Ryan, 1981) used were listed to be B_2O_3, B_4C, BN and B. They found an increased sensitivity for the determination of various epithermal reactions and in addition, yielded much lower detection limits for fast neutron reactions. As noted by (Hanna, 1977), the use of cadmium as a thermal neutron shield is only useful in neutron activation for a small range of neutron energies (0.5 to 2 eV). From there, a combination of boron and cadmium would be necessary to isolate other resonance reactions between 2 and 15 eV. Beyond that boron as a function of thickness would control the energy range of a neutron flux spectrum.

There have been other endeavors in filtration designs that attempted to yield a fast neutron spectrum. Note, this paper acknowledges fast neutrons as occupying the ≥0.001 MeV neutron energies. Mentioned earlier, europium, Eu, has been used to absorb thermal and epithermal neutrons to acquire a fast neutron spectrum in a fast reactor (Mcduffee et al., 2008). Boral, a well-known alloy of Al with some 3-15% of boron content, has also been used to create a semi-fast neutron spectrum (Mohamed & Gaheen, 2016). The most common material, B_4C, in conjunction with Cd, has also been utilized (Bem & Ryan, 1981; Chisela, Gawlik, & Brätter, 1986; Greenwood, Wittman, Metz, Finn, & Friese, 2014; Greenwood et al., 2012). The difference between these facilities and the one specified in this work is the pneumatic system capability and decent fast to thermal/epithermal population and fission ratios. Cadmium was not enough shielding in this work to attain a neutron spectrum close to that of the ^{235}U Watt fission spectrum. It was necessary to combine this material with other thermal neutron attenuating materials, in this case boron powder, as differences in capture cross sections affect the overall neutron spectrum that is being transmitted (Chisela et al., 1986).

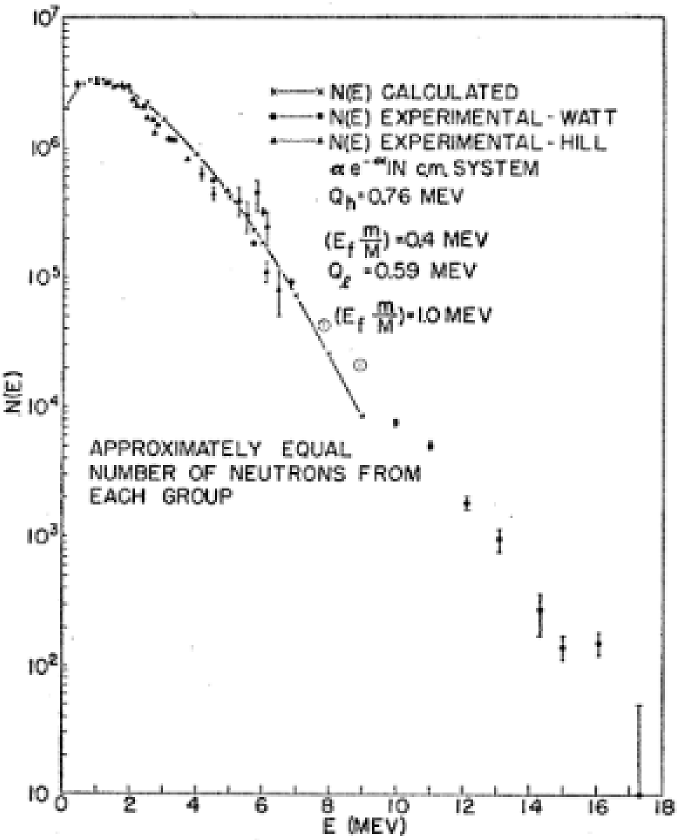

Figure 9: ^{235}U Watt fission spectrum (Watt, 1952).

There also exists a large variance in scattering cross section values per isotope such that the impurities in the selection of materials must be taken with great care. The activation of said materials can also be a hazard during and after irradiations. Therefore, the elemental purity and total makeup of the materials impact safety considerations is needed. The flux shape of the Watt fission spectrum depicts the probability of the production of fission energy neutrons with respect to other neutron energies. The approach to this curve was attempted through combining Cd and B as neutron absorbers.

Prior work (Greenwood et al., 2012) served as a starting point for this design. In their system, a sample was inserted into a container made of $^{10}B_4C$ wrapped with Cd. This container was then sealed and manually loaded into the reactor and then manually retrieved out when it was time to place the sample on the detector. This method was found to be inefficient towards the probing short-lived fission products. Therefore the experiment performed by Greenwood et al. (2012) only provided a guideline in adapting their design to be cheaper, more structurally sound and contain a pneumatic sample transfer system capability which would be able to examine samples at a much smaller volume and with greater ease.

Boron and cadmium have been paired up before (Hanna, 1977; Alfassi, B, Natan, 1984; Bem & Ryan, 1981; Chisela et al., 1986; Hou, Chai, Qian, Li, & Wang, 1997; Landsberger, 1989; Stuart & Ryan, 1981) in shielding thermal-epithermal neutrons. It has been figured out from those experiments that boron based compounds are prone to generating a substantial amount of heat due to the daughter products from the exothermic neutron capture reaction: $^{10}B(n,\alpha)^{7}Li$ (Chisela et al., 1986). Cadmium is no exception to generating heat either as its large thermal cross section means it can absorb a substantial sum of thermal neutrons. But because the neutron capture reaction proceeds as $^{113}Cd(n,\gamma)^{114}Cd$, most of the excess energy is carried out of the system in the form of a gamma ray. The high thermal neutron absorption rates of boron and cadmium ultimately resulted in the heating of both materials which cannot be ignored and was monitored and discussed in this thesis. The production of He-gas due to the boron capture reaction will also be discussed in the later sections of this thesis.

To reiterate, the goal of the following thesis is to provide the design and modeling of a fast neutron irradiation facility implemented in the core of a TRIGA MARK-II reactor. Characterization of the facility as well as fast neutron irradiation studies on nuclear fission products will be done through implementation and creation of the proposed in-core facility. First uses of this facility will be to provide corrections for current fast fission product yields that have been made with large uncertainty. There have been former on-going endeavors in improving these fast neutron induced, short-lived fission product yield values as previously mentioned (Greenwood et al., 2014, 2012; Tonchev et al., 2017). This facility will aim to supplement the needs of the nuclear community by providing an opportunity for scientists to be able to rapidly irradiate and analyze samples with fast neutrons.

EXPERIMENTAL SELECTION OF MATERIALS

Materials Explored and Materials Chosen

The primary neutron attenuating materials chosen for this experiment were a crystalline boron powder enriched in ^{10}B (97%) and cadmium metal. Why was a boron powder chosen out of all the other boron-rich materials used by (Chisela et al., 1986; Greenwood et al., 2014, 2012; Landsberger, 1989)? It was not the first choice. Initially, there was a wider range of prospective materials. These materials were YB_{66}, cubic(c)-BN, hexagonal(h)-BN, B_4C, and Boral. Within researching each of these materials, structural stability was examined, cost was estimated, and more importantly, synthesis methods to attain such materials were viewed for experimental feasibility.

An initially promising material, YB_{66} (and other Yttrium Borides: varied values of $YB_{\#\#}$) was examined through methods of creating the material from inception. The cost to produce YB_{66} was on the order of $3000 as it was made most commonly through Chemical Vapor Deposition (CVD). This was to produce it on a scale of small crystals as larger productions of this material are not physically possible today. Adjacent to the financial risks, the material YB_{66} contained some useful properties such as its high boron density 2.22147 g cm^{-3} and thermal stability. A negative property of the material is the metal borides ability to hold high gravimetric densities of hydrogen. This would work against what this project aims to succeed. The interaction of hydrogen nuclei with neutrons (billiard ball effect ~ equal size effect) causes the thermalization of neutrons. The hydrogen content may be removed through sintering at high temperatures but to make the quantity desired is still both scientifically and economically out of reach.

The next material of interest is h-BN. Boron nitride is a hard, white material (or powder) which is comparable to that of the hardness of diamond (truer for its cubic-BN counterpart). This material has a relatively low thermal expansion unit, $0.5 \rightarrow 12 \times 10^{-6}\ {}^{o}C^{-1}$, which means that it is excellent when it comes to taking on large amounts of thermal energy that it may experience in a reactor during irradiation (Lipp, Schwetz, & Hunold, 1989). The material is non-toxic, microwave transparent, easily machinable, chemically inert, and has a good thermal shock resistance. Ultimately, h-BN was not utilized despite said characteristics because of the difficulty and risk associated with creating an enriched ^{10}BN ceramic. Each contacted company either denied the request to make the material or stated that they could not do it because of the starting materials were not readily available. This was the exact problem experienced by (Greenwood et al., 2012) and because of the personal feedback received from their experience, it was decided that this was not something that could be used, since both BN and B_4C are ceramics that are similarly sintered and therefore would produce equal costs in their production. The issues presented above would overall cause the ideas to then be scraped for a new design and boron-rich materials.

The discussion now falls upon the potential of c-BN rather than h-BN or h-$BNSiO_2$. They are referred to as cubic and hexagonal because of how the atomic nuclei are arranged as seen in the crystallography of the materials (Sands, 1993). The cubic structure has a denser packing of atoms which makes it more physically dense and harder than a hexagonal structure. As a result, it requires more difficult and costly preparation methods. Absent the consideration of cost, c-BN would be the desired material. It is denser in boron content (1.438164 g cm^{-3}) than hexagonal-BN (0.87541 g cm^{-3}) or hexagonal-$BNSiO_2$ (0.57068 g cm^{-3}) (Mukasyan, 2014). Density unfortunately, is not the only factor at play. As previously noted, the production costs of cubic-BN are significantly more expensive than hexagonal-BN. A significant portion of production facilities are not even able to produce the enriched ^{10}BN, rather they are restricted to the production of the natural quantity due to too high of a risk.

Another boron-rich material was considered for comparative reasons was boron carbide or B_4C. This was the material used by (Greenwood et al., 2014, 2012) where their research was aiming to achieve the same outcome of this facility. They incorporated this material to mitigate the thermal neutrons from a reactor to achieve a predominantly fast neutron spectrum. Their problem was not necessarily boron density based, as its boron density achieved nearly 80% of their total material density (1.93904 g cm^{-3}), it was the cost of building it. The brittleness of the material was a major factor. The company whom this researching team had built the irradiation cylinder was struggling to build and sculpt the cylinder without fracturing it. This resulted in numerous costly iterations for the company to achieve the desired result which lead to their refusal of future business ventures. Not only was the construction of the capsule costly, but as noted from the purchases made for this project, 1 kg of ^{10}B powder enriched to >96% cost $25,000. Therefore, the amount of frustration experienced by the company is highly understandable. Despite the difficulties, the results of the facility can be noted in (Greenwood et al., 2014) and will be compared to the results achieved by this facility.

The nearest and perhaps simplest boron dense material that could be found was that of a crystalline powder of boron. After various MCNP iterations detailing its promise, this material was decided to be the sole boron-rich material of choice. It also posed the simplest design and was a ready to use material. This powder was purchased from the company 3M at $25,000 for 1 kg. Having the boron in powder form allows for the option of a variation in thickness of the boron content at no cost to the user (so long as the volume required is already purchased). The one major downside of the boron powder is its low thermal conductivity (Stein, 1954) and its $^{10}B(n,\alpha)^{7}Li$ neutron capture reaction. The combination of the two prove to produce an appreciable amount of heating if no coolant is present (Chisela et al., 1986). This issue was partially remedied by the addition of cadmium along the outside of the boron powder such that the bulk of the thermal neutron flux would be absorbed prior to interacting with the boron powder. After a few MCNP iterations on the variation in thickness for Cd, the optimal value was found to be between 0.5-1 mm (Abrefah et al., 2011; D'Mellow et al., 2007; Greenwood et al., 2014). Adding cadmium was a cheap solution and was also a readily accessible material from the company Shieldwerx at $1250 for two 0.5 mm rolled sleeves of Cd, 60.96 cm in length. The optimal thickness of the 97% enriched ^{10}B powder at the maximum theoretical density of 2.17 g cm^{-3} would be computationally determined to be ~2 cm (Greenwood et al., 2012) but later modelling constraints would limit this thickness to ~ 0.998 cm. If the density is less than specified above, then the addition of more ^{10}B content per unit volume is necessary to modify the reactor spectrum to more closely fit a Watt fission shape. This would mean that the thickness would need to increase from 2 cm as the volume decreases. Note, the approach to a Watt fission spectrum is highly dependent on this detail as Cd serves to only remove thermal neutrons while ^{10}B is really the only easily procurable isotope that has a constant cross section of the epithermal region of a neutron spectrum.

The materials and designs formerly presented paved the way to a cylindrically layered setup. This layered material approach offered a simpler and more facile method to attenuate thermal neutrons. The following layering approaches depict a magnitude of layering attempts that were made before reaching the final design. Some designs were performed with a (from outer most to inner most layers) Al-Cd-$^{10}B_{pow}$-BN-QG while others were done with a (Cd)-Al-$^{10}B_{pow}$-BN-QG design (QG = quartz glass). These were varied in material thicknesses to gauge the best component design. The many models that were done implementing these variations will only be mentioned as such to provide background in the attempts and considerations given to different designs. A section prior to the final design will shed some light on these layering choices. In the final design, a Cd sleeve was placed on the inside of an Al annular canister which separated the internal components from the pneumatic system. The enriched ^{10}B powder was then packed on the inside of this layered cylindrical system. The Cd placement served to shield the boron powder from an incident thermal neutron flux to prevent the excess generation of heat. The use of Al 6061-T6 throughout the system was done for the predictable types of radiation it emits as well as its great withstanding to radiation. The final layering design was chosen for three main reasons: neutron cross sections, water damage and heating effects. Because Cd was not a very structural material, it was shifted to be inside an aluminum canister. Cadmium also absorbs neutrons at a larger cross section than boron does at thermal energies, for this reason it was chosen as the first line of defense against thermal neutrons. Then followed the enriched ^{10}B powder as it dominated in the resonance region which is primarily where the thickness of the enriched B present per unit volume applies. In this region, the ^{10}B capture cross section knocks down the tail end of the fast flux to approach Watt-fission spectrum linearity.

Implementation of Materials into the Design

The finalized set of materials that were chosen for uses in neutron attenuation were enriched ^{10}B powder and Cd metal. Silver, Ag, was also a material that yielded promising results in its resonance absorption and heat sink capabilities. Unfortunately, due to dimensional constraints, this material was scrapped.

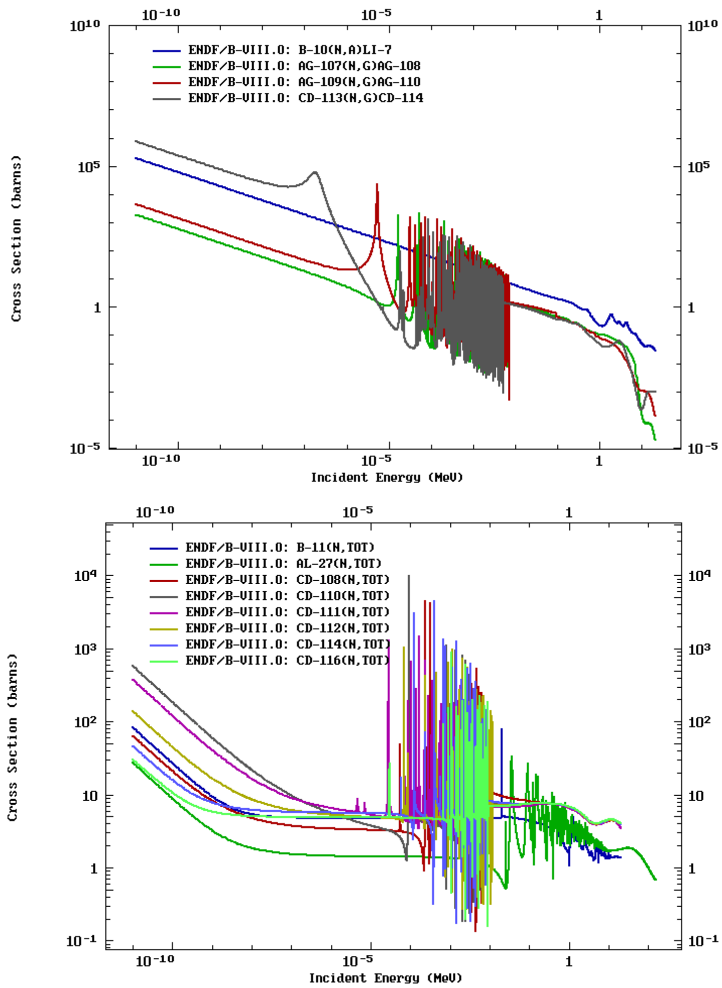

Figure 10: Cross section values of the materials implemented into the thermal filtration design (Brown et al., 2018).

The materials and layering format involved in the selection of materials was done through means of their cross-section values working in conjunction with one another. This means that the materials with the larger thermal cross sections would be placed on the outside and those with the next largest cross section would be placed subsequentially afterwards. For example, in Figure 9 (previous page), the order of material placement between a bare reactor flux and a sample would ideally be: ^{113}Cd, $^{107/109}$Ag and ^{10}B. The latter two components could also be alternated in layering depending on the flux requirements.

The materials were chosen based on their structural integrity, activation products, thermal neutron absorption cross sections, and a near non-existent total fast neutron cross section. The design of the system was made to be cylindrical to provide practical methods of delivery of samples to and from the irradiation facility. Smaller, simpler models were ran using spherical designs which provided more uniform results as the flux would indeed be but the practicality as well as the implementation of such a design (building everything in a spherical shape) would be quite costly and more than likely not worth the effort. As noted in the introduction, boron and cadmium were obvious candidates for thermal neutron attenuation as the capture cross sections for thermal and epithermal neutrons are both very large. Their resonance ranges also do not interfere with the fast neutron spectrum, defined to be above 0.001 MeV. Having these two materials posed subtle challenges in implementing them in the core of a reactor as heating effects can take hold and/or their effective decrease of the reactivity of the reactor core. To create a delivery system (ie: pneumatic system) the incorporation of various other materials was needed to attain a solid, radiation resistant structure as Cd has been known to peel and deform at minimal thicknesses (D'Mellow et al., 2007). Due to its potential for structural deformation, an Al casing was implemented outside of the Cd layer to prevent structural deformities from occurring. Luckily, the implementation of these materials into the reactor core was made a little easier as this work takes advantage of a previously implemented 3-EL facilities 6061-T6 Al insert into the core.

Silver was previously mentioned as a suitable material for this system. This element was considered because of its large epithermal resonance peaks beyond the Cd range of absorption and its excellent heat transfer capabilities which makes it ideal to be placed next to or within the boron content. The downside of Ag was the comparable levels of radiation it emits when compared to Cd. The activation of Ag has such long half-lives that it would prove to be more of an issue than Cd in removing the 3-EL facility from the reactor pool. This could prove to be fatal in research utilizing this facility, especially if something was needed to be removed from the 3-EL shortly after being irradiated. Therefore, the addition and exclusion of silver occurred late in the process of developing the fast neutron irradiation facility. It was ultimately removed because of the potential for activation and the limitation of ^{10}B content per unit volume.

ANALYTICAL CODES USED FOR RADIATION CALCULATIONS

MCNP 6.1.1 beta

The analytical code MCNP is a general-purpose, continuous-energy, generalized-geometry, time-dependent, Monte Carlo radiation-transport code created to model and track various types of particles over energy ranges (often broad) deemed useful in nuclear engineering (Goorley et al., 2013). It was developed by Los Alamos National Laboratory and is currently on the second version of its sixth installment to the software. MCNP6 is the sixth installment to the MCNP catalog where it was made to combine the codes MCNP5 with MCNPX to utilize the features offered by each. For more information on the origin of the code see (Goorley et al., 2013).

MCNPX/MCNP6 (eXtended/6) was utilized in providing the theoretical approximations of nuclear interactions as well as all 2D/3D models. Neutron interactions with matter were monitored via their energies through MCNP calculations. The flux across each material was determined by the preceding materials ability to capture thermal neutrons. Utilizing the flux and lethargy of an F4 tally and/or FMESH tally, the neutron flux distributions were plotted against their respective energies to view the effective "filtration" of the thermal neutrons. Alongside said distribution calculations, the heating caused by the constant irradiation was also found using energy deposition (F6/+F6) tallies through MCNPX/MCNP6 modeling. In the making of the models of the effect of a neutron flux on the pneumatic system, a highly accurate TRIGA MARK-II reactor model was used. This model was designed to be geometrically accurate in representing the current UT Austin TRIGA MARK-II reactor. The makeup of the system was computationally time intensive such that the implementation of variance reduction techniques were used, particularly weight window generations. This form of variance reduction greatly reduced the computational time required and served to accurately represent what was indeed going on in the lower neutron energies that were not originally present in the first weight window file. Originally a magnitude of simpler model designs was utilized but the accuracy and the speed at which the formerly mentioned TRIGA model operated at outperformed the need to have a reference model (as the simple model was to be designed for speed and approximations only). Prior to acquiring the reactor model however, many design implementations were used in attempting to figure out the optimal design of the materials and facility for the in-core fast neutron irradiations.

SCALE 6.2.3

Much like MCNP, SCALE was conceived by a national laboratory, Oak Ridge National Laboratory. SCALE is composed of a suite of tools that are useful for modelling and simulating nuclear systems. The outcome can be applied towards reactor physics, radiation shielding, criticality safety, sensitivity and uncertainty analysis, etc. (Rearden et al., 2013). SCALE and MCNP are also alike such that they share the latest nuclear data libraries, depending on the version of each program, for continuous-energy and multigroup radiation transport.

The usage of SCALE in this thesis served to supplement the final generated MCNP results and to ultimately better understand the types of fission products and their associated activities over the course of irradiations and decay (count) times. The SCALE model that was used consisted of a KENO-VI depletion model where the depletion of the sample in the 3-EL was monitored. The depletion reactor model is a near replica of the MCNP reactor model, geometrically. The depletion model is however different in that it contains more precise isotopics of the fuel in the reactor core than utilized in MCNP. These models were compared for similarities in reactivity changes upon insertion of the 3-EL and Pu. This analysis also supplemented with a subsequent study where the MCNP F4 tally could be inserted into a COUPLE module to generate an F33 file to then insert into an ORIGEN module to provide irradiation and decay data to compare against. These two analyses were weighted to one another in order to match their fission product generations.

EXPERIMENTAL: COMPUTATIONAL APPROACH, PART 1

Design 1 & 2: Spheres and Cylinders, Results

The applications of BN to thermal neutron irradiation can be seen below. A neutron flux tally was placed on the outside and inside of the shell while a ^{235}U Watt-fission spectrum point source was placed about 10 cm away in an environment of water (to be a representative reactor core). The model was simulated with varying thicknesses of BN to determine its effectiveness on the attenuation of thermal/epithermal neutrons.

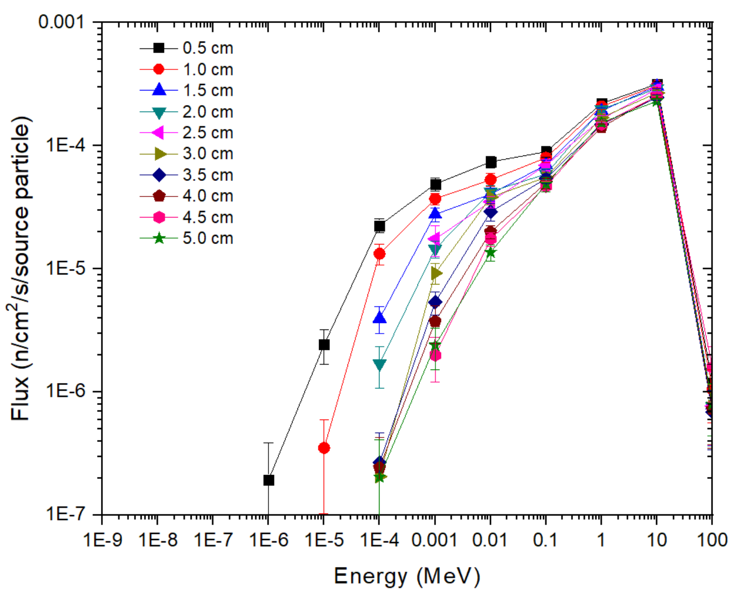

Figure 11: MCNPX output of the attenuation by BN from a source (10 cm away).

Figure 11 shows the thermal neutron attenuation of a varied thicknesses of a BN spherical shell. The increase in thickness revealed that the neutron flux above 0.1 MeV remained largely unaffected whereas the lower energies were more majorly impacted. This figure served as a first order approximation in determining the amount of boron content needed between a bare flux and a sample. For comparison, the 2-3 cm flux shown above is close to the estimations made by (Greenwood et al., 2012) where they utilized 2 cm worth of a boron rich material, B_4C.

A 0.6 cm thick ^{nat}BN sample was irradiated in beam port 5 of the UT TRIGA Mark II research reactor to image the flux before and after interactions with the sample. This beam port is adjacent to the reactor core and is composed of primarily thermal neutrons. The image results can be seen below with a figure of intensity for comparison.

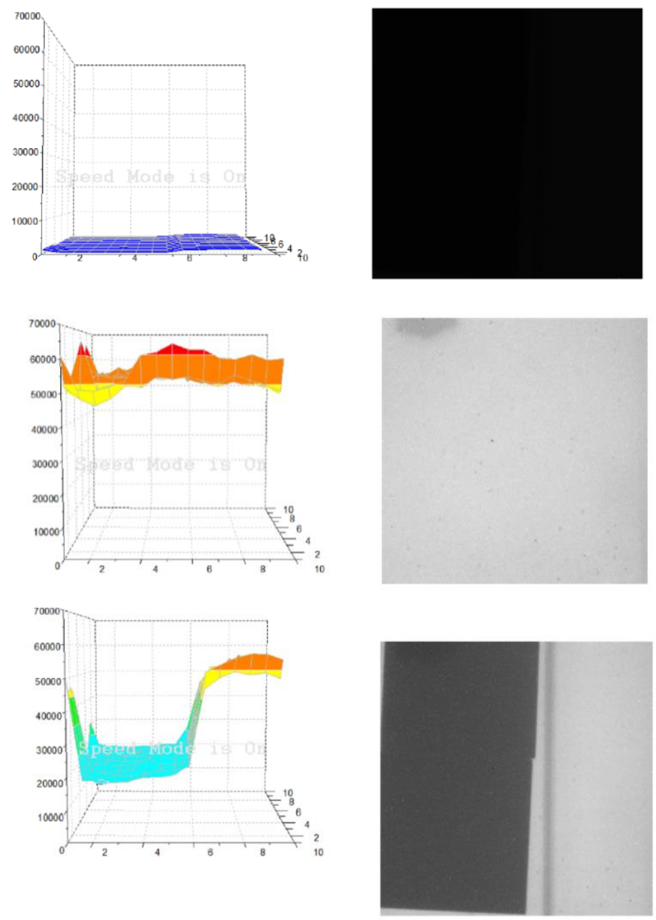

Figure 12: Neutron imaging results of two 0.6 cm BN samples (top: background, middle: no attenuator, bottom: with 2 samples).

The first image is a background, second image is the neutron beam with nothing in the way, the third image is with a 0.6 cm BN plate. As can be seen, a magnitude of reduction of neutrons was about 65%. This value is quite good for being achieved for natural BN via its neutron attenuation. An enriched sample of ^{10}BN would be expected to improve the attenuation 5-fold as the enriched boron would have 5 times as much ^{10}B than that of ^{nat}B.

Figure 13 shows the calculated results directly from the neutron camera estimation results in Figure 12.

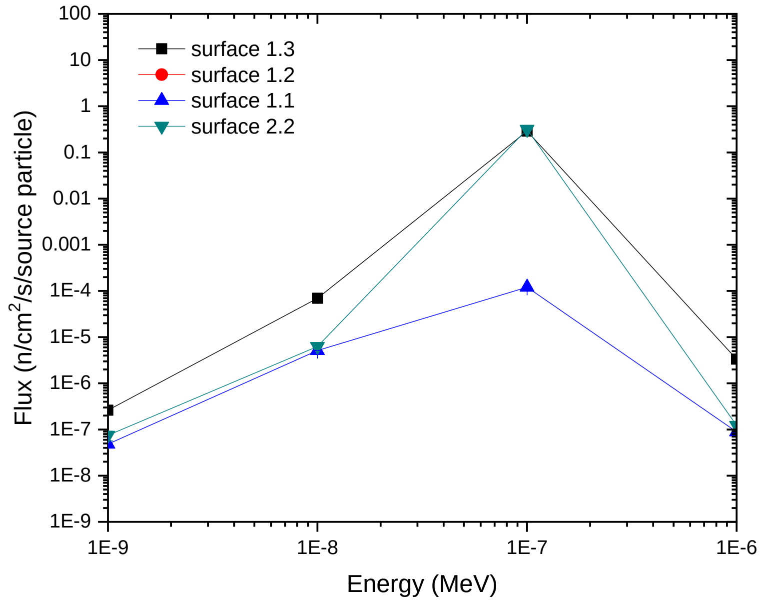

Figure 13: Graphical Representation of the above images and the depiction of the thermal neutron stopping power 0.6 cm natural BN has on a 0.0253 eV neutron beam.

Let it be noted that surface 1.1 refers to the cylindrical side of the BN disk. Surface 1.2 and 1.3 refer to the top and bottom of the BN disk respectively, and surface 2.2 refers to the top of the source shell defined in the MCNP geometry run (Goorley et al., 2013). As can be seen, the thermal neutron attenuation from a 0.6 cm thick BN sample resulted in a 65% order of magnitude drop which is good but not great as we will see in the following section what was achieved with a more simplistic approach to the attenuation of thermal neutrons.

The BN material was still utilized in the following section application of layered material. It was used because it provides a good structural stability as well as another layer that can reduce incoming thermal neutrons. The results of the attenuation of neutrons from the camera and this MCNP run also roughly match up in stopping power (both estimate 60-65% reduction) which gives confidence to the correctness of which code was used.

MCNP Applications and Results

A layered material approach was first thought of to offer a simpler and more facile method to attenuate thermal neutrons. This approach was made easier with the use of enriched ^{10}B powder instead of ^{10}BN as the primary neutron absorbing material. The theoretical density of pure boron powder is (2.34 g cm^{-3}). This value would be comparable to the density of boron in B_4C (1.93904 g cm^{-3}). Another advantage of boron powder is that we are now able to neglect the structural stability of our material that will be absorbing the most radiation from neutrons as the powder has no structure to sustain. And supposing when the material is "spent," all one needs to do is empty it out and replenish it with more boron powder as it reaches its lifetime. The use of a thin Al-shell was for the predictable types of radiation it emits, great withstanding to radiation and short half-life. Within the Al-shell follows the ^{10}B powder which can vary in thickness so long as an interchangeable Al-shell is present. Then follows either the quartz glass layer, which separates the B powder from the sample to be irradiated via a preexisting pneumatic system, or the BN layer, which can either be enriched or not -as it does not change much over the thicknesses allowed for this layer. On the outside is the option of adding an additional layer of Cd metal to improve structure and any background irradiation that may be incoming. This layer was quite thin, about 1 mm, so it was shown to be relatively transparent to the neutron spectrum.

Setup

Within the MCNPX (Vised) modelling, two approaches were taken: initially, spheres were used for the layering out of simplicity, then, right circular cylinders were utilized for a more practical model of what would be made in conjunction with a pneumatic delivery system in the real reactor applications for fast neutron activation analysis.

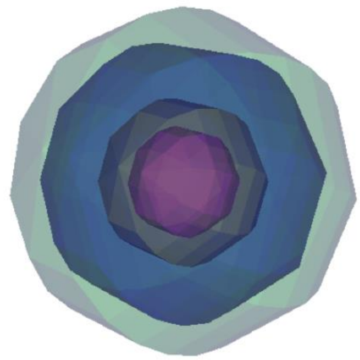

Figure 14: 3D-view (MCNPX Vised) of the first layered material approach for thermal neutron attenuation Al-B_{pow}-QG.

Above is the spherical model approach where a point source is at some distance away. Below is the more geometrically exact model of a cylindrical canister of materials with a planar source underneath it. Both sources in each of these examples were of the ^{235}U Watt-fission spectrum as this "neutron filter" would be placed in or above the reactor core. The environment of each example was water to provide a better reactor core approximation.

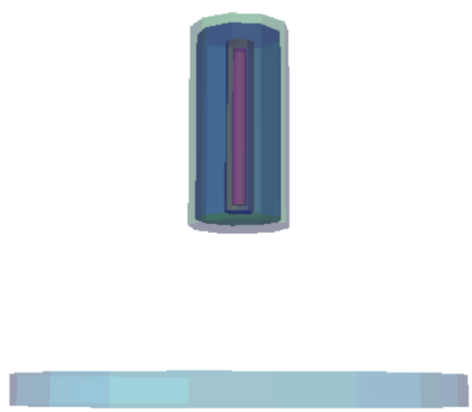

Figure 15: 3D-view (MCNPX Vised) of Al-B_{pow}-BN layered material subject to a planar neutron source.

As before, MCNPX was utilized in determining the neutron attenuation abilities of this array of materials. These runs however involved much larger amounts of source particles (>10^9). This allowed for better statistics down in the lower energy range not seen before. It inevitably also yielded greater run times. Noted in Figure 15, this MCNPX run involved the use of quartz glass instead of BN as a separator between the natural boron powder and void inside the quartz glass shell in which a sample would be irradiated. This serves as one of the many iterations of design ran in creating this facility.

Flux tallies (F2) were defined at the surfaces of each material where the output in Figure 16 is the neutron flux per source particle. Graphed along with each materials surface flux is the flux of the source itself in a vacuum and in water for comparative analysis of the two. Looking at the results one can conclude that even more particles are necessary so that the graph can extend all the way to the 10^{-9} MeV range.

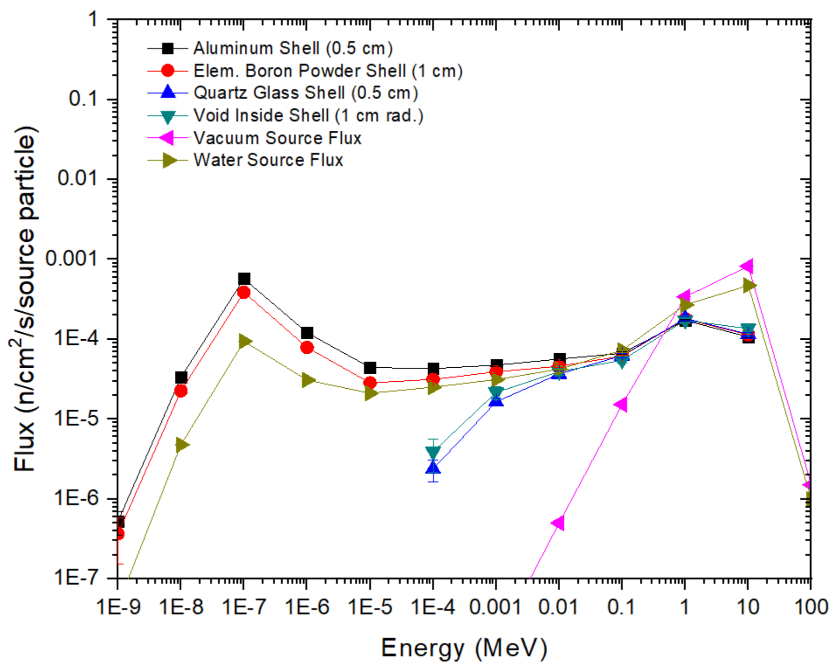

Figure 16: MCNPX output of layered model in water with a point source 10 cm away.

The model above utilizes a natural composition of boron powder. This can quickly be determined to be effective against thermal neutrons but less so against epithermal neutrons. Being an elemental powder means that only 20% of it is providing any real chance in capturing neutrons. Therefore, the implementation of enriched boron powder and BN was made.

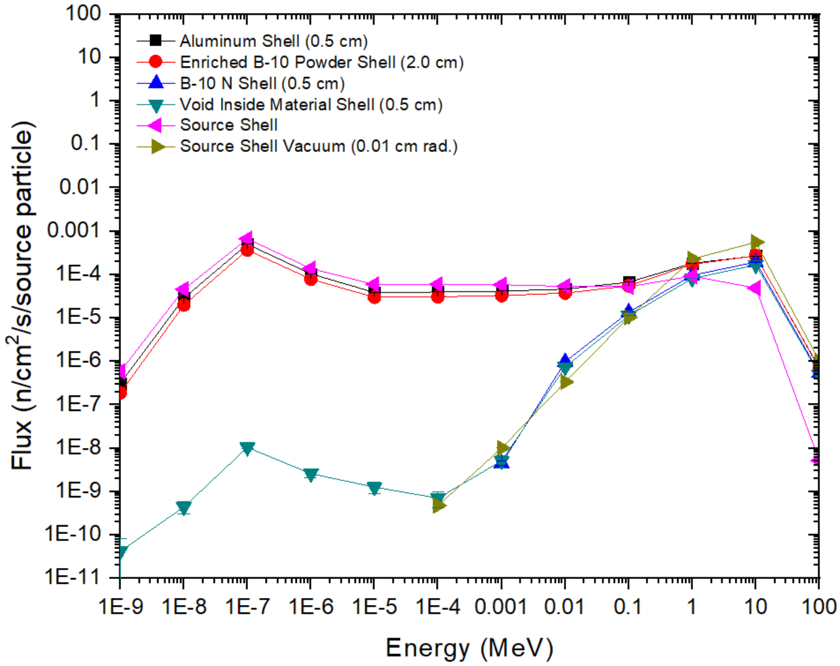

Figure 17: MCNPX output from a larger computer running of the above Figure, Al-^{10}Bpow-^{10}BN layered materials.

Looking at Figure 17, it is obvious that the enriched powder and BN addition perform much better in attenuating thermal neutrons. The greater thicknesses the ^{10}B content is primarily the reason for this. The spectrum now extends nearly all the way down the range of the graph. It is also easy to note that the reduction of the very cold neutrons in the 10^{-7} to 10^{-9} MeV range is of orders of 10^5.

These runs on an average computer can take anywhere from an hour to days and even weeks depending on the processor and number of particles designated in the problem. For better graphical results and more plot points, more particles were needed which required a more powerful computer. This is where the "MCNP cluster" runs come into play. This computer was built a while ago, but it can still run MCNP decks about 10-15 times faster than a basic laptop could.

Seen in Figure 17, the spectrum of thermal → cold neutrons are now visible in our data. This helps in determining exactly what is going on in our entire energy range whereas before we were blind to such neutron fluxes at energies below 10^{-4} MeV. With what we have produced thus far, it seemed to make sense to gauge the effects of adding another layer. This ended up being the addition of 1 mm Cd on the outside of the Al-shell.

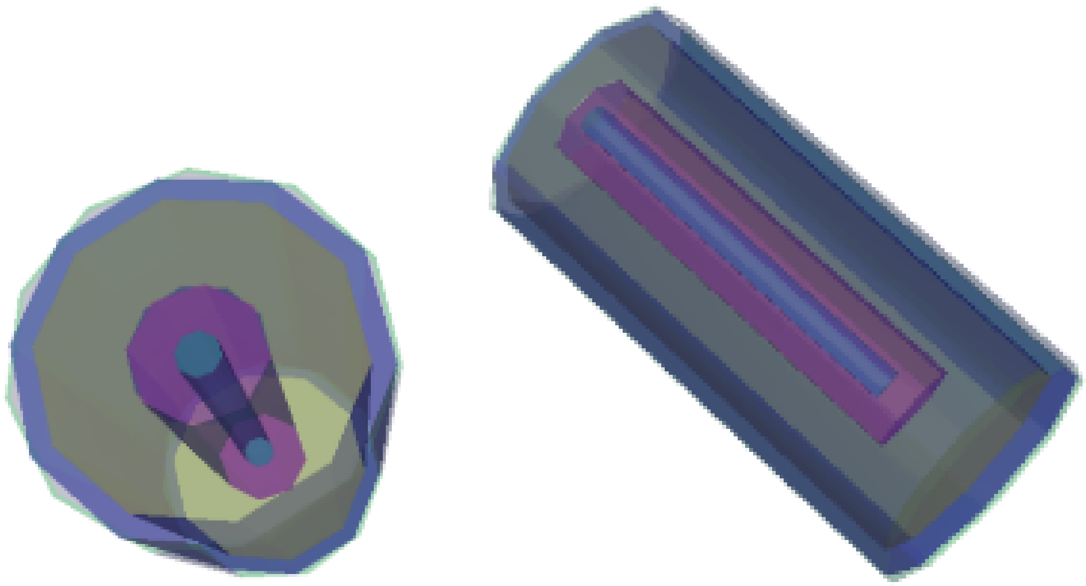

Figure 18: 3D-view (MCNPX Vised) of Cd-Al-B-BN layered material.

Figure 18 simply show the cylindrical irradiation container with the addition of Cd which almost seems like nothing, but it is given to show how a minute addition of a material greatly affects the incoming neutrons in terms of their initial flux when hitting the cylindrical vessel. It was not mentioned explicitly before, but the thickness of each materials as presented in the cylindrical shell is as follows: Al: 0.5 cm, $^{10}B_{pow}$: 2.0 cm, ^{10}BN: 0.5 cm, and Cd: 0.1 cm. The bottom of the sample which is to be directly facing the reactor core is that of which there is spacing in the base, which in Figure 16 is the lower end. This spacing is to account for an overall equal irradiation from the reactor as it is equivalent to that of the sides (when first made into a cylindrical MCNP model, this was not the case).

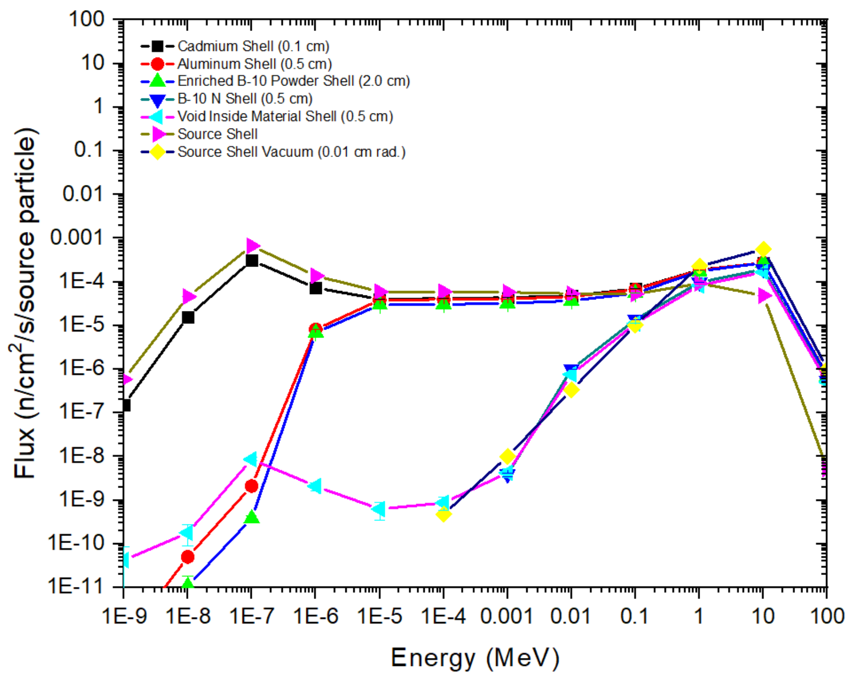

Figure 19: MCNPX output from a larger computer running of the above Figure, Cd-Al-^{10}Bpow-^{10}BN layered materials.

With the implementation of using the MCNP cluster computer, running 10^{10} particles is now feasible in just under 3 days. With doing so, Figures 17 and 19 can be compared with the only difference being the addition of 1 mm Cd on the outside. It is seen that in Figures 18 below that the neutron flux dramatically drops 10^7 orders of magnitude at 10^{-8} MeV when compared against Figure 16 and Figure 17. This is simply because of the neutron capture cross section that ^{10}B and ^{113}Cd have at those energies. Although as dramatic a drop as it may seem, the effect of adding Cd onto our layered system is quite minute in neutron attenuation as is seen in the following figure.

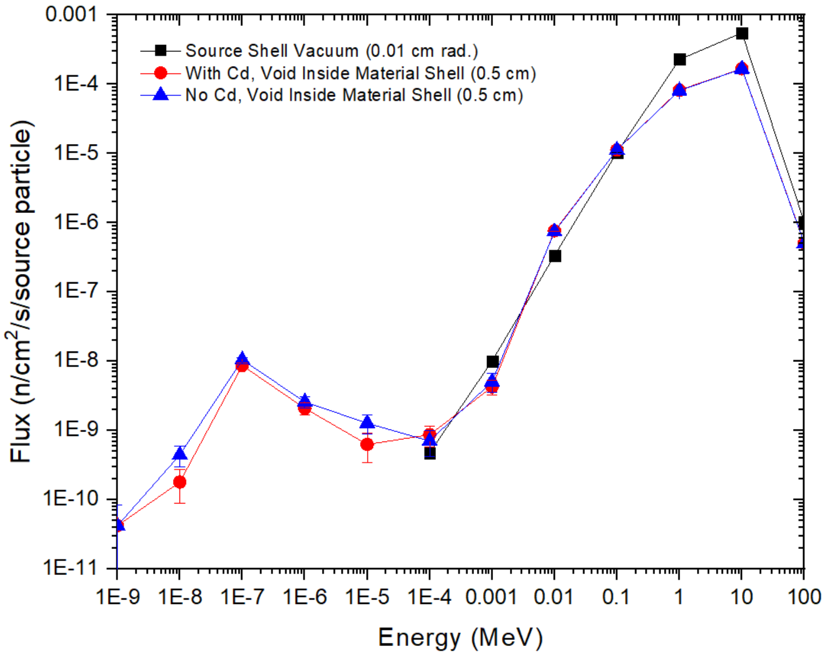

Figure 20: MCNPX output comparison of both with/without the cadmium layer.

The addition of 1 mm Cd hardly shifts the flux at all which, as seen in the following sections, leads to the reduction in Cd from 1 mm to 0.5 mm. It will be shown that it does help significantly in the heating of the materials in the upcoming sections detailing the use of F6/+F6 tallies and steady state heat transfer approximations to predict how hot the irradiation facility may get.

Another thing of note was the application of this material in MCNPX Vised to the plotting of particle tracks. This was done for a more realistic view of what is going on with the neutrons during irradiation. Below is a couple of figures which represent such plotting:

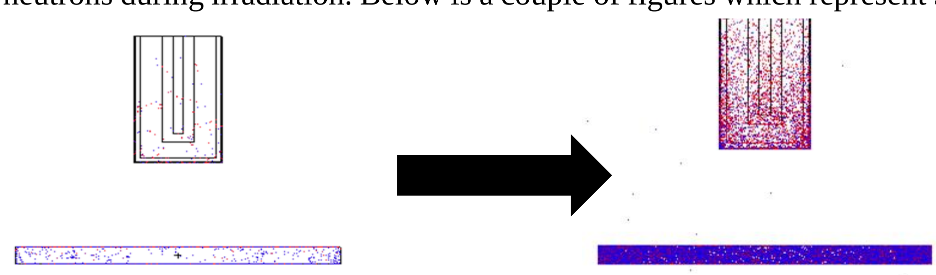

Figure 21: Depiction of low energy (blue) neutron attenuation and high energy (red) neutron transparency.

It is quite easy to note the larger densities of high energy neutrons as compared to the low energy neutrons in the two images above in which is very indicative of all the data we have presented thus far. These tracks not only agree with what has been tested day after day but also enlighten those whom do not understand what the output data may represent; in other words, it gives a very good conceptual view of what is happening with the system which to an extent cannot be provided by numbers and charts. Using a source plotter in the MCNPX Vised GUI, tracks of neutrons, from a pool of 1000-10,000 or so, were plotted throughout the geometry of the MCNP model. The indication of high energy (above 1 MeV) and low energy (below 1 eV) was easily made to be distinguished by a red and blue color. The first image just represents a particle plotted collisions throughout its interaction range. It can be noted that most of the neutrons are indeed trapped in the ^{10}B powder layer of the system as they tend to clump up in that region. Only a couple make it past this layer which points to the incident flux on a sample consisting of high energy neutrons.

Design 3: Reactor Model Implementation, Results

The following approach to modelling the fast neutron irradiation facility more accurately was done through the implementation of the materials into a pre-existing MCNP model of the TRIGA Mark II reactor, put together by alum William H. Wilson in 2015. The location of the irradiation facility was finalized to be in the 3-EL since this is the largest insert into the reactor core that we can currently achieve, minding the 7-EL which requires the shuffling of fuel and its modified spider attachment to the grid plate. The future use of the 7-EL will be discussed in detail in the concluding sections.

The reactor model was modified to remove the fuel elements in the 3-EL to fit the 3-EL insert into its respective location. Setting the layering of the previously mentioned materials into the following insert results in the restriction of both the sample size and amount of material that can be put between the sample and the thermal neutron flux of the TRIGA reactor. This restriction resulted in the optimization of materials to sample size in the 3-EL.

The design of the experiment implemented the chosen materials into a closed ended, cylindrically layered format, inside the 3-EL insert. The material makeup of this insert is the aluminum alloy 6061-T6. The size of the Al tubing is 4.468 cm inner diameter and 4.763 cm outer diameter. The length of the Al tube is 122.238 cm. The total length of the entire insert, tip to tip, is about 127.953 cm.

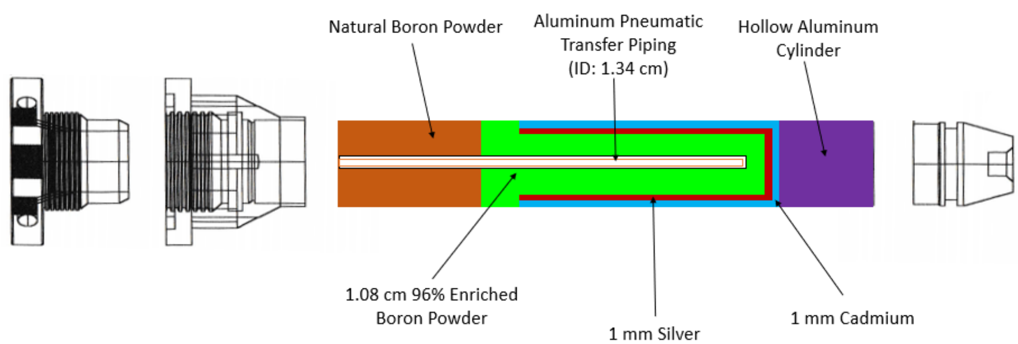

Figure 22: 2D schematic of the 3-EL insert and its constituents.

The length of the Cd, Ag and ^{10}B layers are made to be, for simplicity, all equivalent in length (139.878 cm, fuel pin length). The length of the Cd sleeve is 60.960 cm, the length of the Ag sleeve is 37.465 cm and the ^{10}B length is adjustable between the two with a maximum volumetric occupancy of ~ 461 cm^3. A table of the values can be found below:

Table 2: Measurements of the materials to be implemented into the 3-EL design.

Material	Length (cm)	Inner Diameter (cm)	Outer Diameter (cm)
Al tube (3-el)	122.238	4.468	4.763
Cd sleeve	60.960	4.267	4.468
Ag sleeve	37.465	4.069	4.267
B powder	40.005	1.905	4.069
Al Pneumatic Piping	N/A	1.340	1.905
Quartz Glass Sample Size	10.160	0.900	1.180

It is necessary to note that during the MCNP iterations following this design, the density of the enriched boron powder was thought to be the theoretical 2.17 g cm^{-3}. This came from the quoted value given by 3M, the company from which the powder was purchased. Figure 23 depicts the design of the fast neutron irradiation facility implemented in the reactor model.

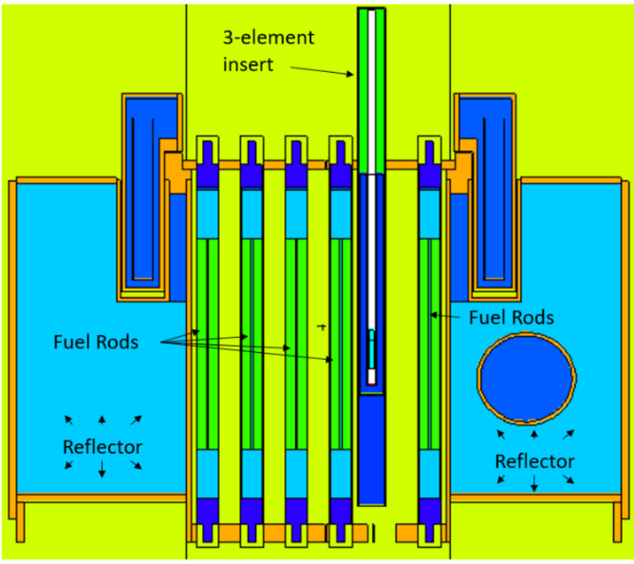

Figure 23: Vised 2D model of the 3-EL insert.

This 2D model depicts a slice view of the TRIGA reactor with the fast neutron irradiation facility being the blue colored pipe among the green colored ones (fuel rods). In the assurance of the design, the k-values of the system (and hence the reactivity changes) were monitored which included computational runs: without anything in the 3-EL (k = 1.04168 ± 0.00028), with the 3-EL insert placed in but not a sample (k = 1.03552 ± 0.00051), and with an 80 g sample of Pu (k = 1.03623 ± 0.00058). The resultant k-values were calculated using the following equation:

$$\rho = \frac{k_{eff2} - k_{eff1}}{k_{eff2} \cdot k_{eff1} \cdot \beta} \tag{9}$$

where k_{eff} is equal to the outputted value given by MCNP and β is taken as the delayed neutron fraction which is equal to 0.0067. The addition of 80 g Pu served as a test for determining the fast nature of the neutron flux spectrum. This turned out to be a paramount achievement to the design of the fast reactor spectrum achieved through this system where the change in reactivity from adding this was only +$0.0988 (insertion of 3-EL into core resulted in a decrease of reactivity of about -$0.8523). If there existed a significant enough fraction of thermal neutrons entering the system, then we would have expected the addition of weapons grade Pu (of even 1 g) to have made a much larger, positive reactivity change upon sample insertion.

MCNP Results

The MCNP outputs for the model that has been presented showed great promise in the attenuation of thermal/epithermal neutrons. Despite the incorrect use of density for the enriched powder (discussed in later section), the results still yield a ballpark estimation of what the 3-EL facility constraints might achieve and details the interesting effects each material has in attenuating neutrons.

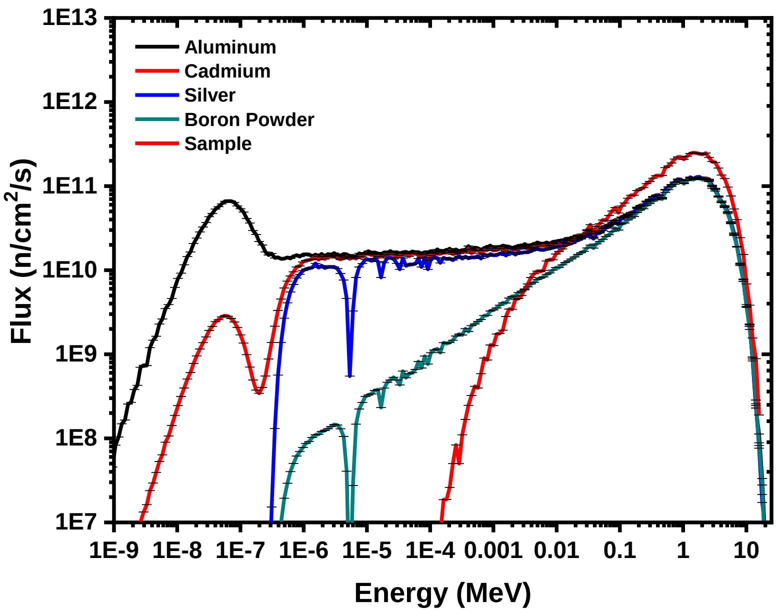

Figure 24: MCNP model of the fast neutron, 3-EL insert.

Figure 24 presents an interesting feature in which some might think is a red flag that the modelling presented is incorrect; why is the fast flux that is hitting the sample larger than that in the overall 3-EL insert? At first glance, this small discrepancy gave pause. The answer was found out to be a feature of the F4 tallies in MCNP. Since these are cell-averaged tallies (volumetric), the volume of each material is utilized to average the neutron flux over the entire length of the material. This is the key to the problem as the 3-EL insert (and most of its internal components) lies both inside and outside the reactor core, therefore the upper portion of the 3-EL sees far fewer fast neutrons than the lower portion. And because of the distinct sample size used, the entire sample ends up submerged in the core, as intended, so that it would receive as constant a flux as possible. Therefore, the samples result in the fast flux region are averaging over a totally fast spectrum whereas the other material shells see more of a distribution, therefore the average fast flux in the other shells are found to be a bit lower. This was proven to be correct when the sample length was extended to the length of the outer cell lengths. The plot in the above image was performed using 250 logarithmic spaces from 10^{-11} MeV to 25 MeV. It is graphed as flux because it is not dividing out the flux by the difference of the natural log of the individual neutron energy bin spacings. This plot details flux only, not the distinct changes in neutron energy, i.e. lethargy. Lethargy for this application scraps absolute scale of flux in exchange for the qualitative representation of changes in neutron energy. It is not plotted in this iteration because the bin width is not reflective of cross section data, but it will be shown in the final design approach and discussed in much better detail in that section.

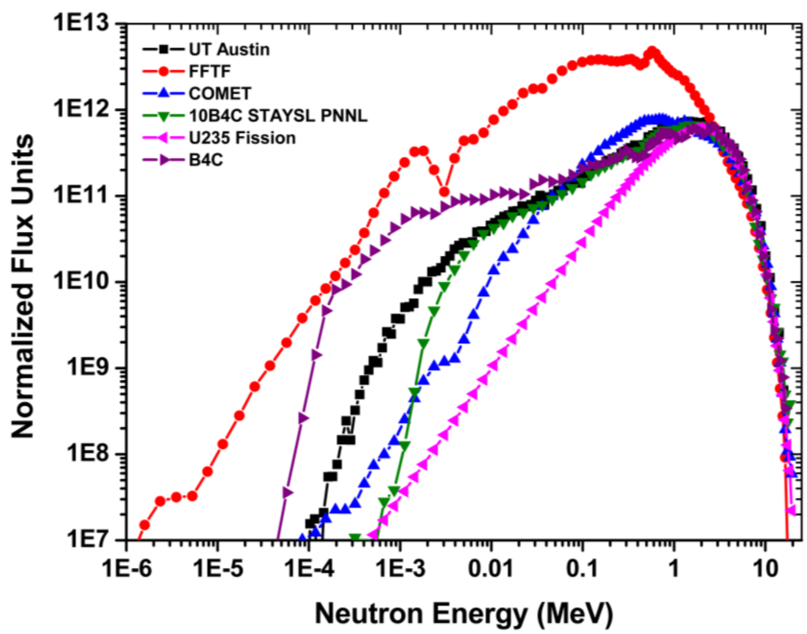

Figure 25: Comparison of the fast neutron, 3-EL insert to various fast neutron facilities (Greenwood et al., 2014).

The flux in Figure 25 is compared against various known fast flux facilities that have existed over the years. The data for this figure was pulled from (Greenwood et al., 2014). The units in Figure 25 are also normalized to fit all the neutron spectra on the same graph, meaning the flux values are arbitrary. The implementation of a fast neutron irradiation facility at the University of Texas at Austin MARK-II TRIGA research reactor seems to be an extremely promising and plausible experimental facility. The two most important features of the neutron spectrum are the flux shape and the flux magnitude. Figure 23 only serves to depict the shape of the spectrum to show the distinct features of each facility. One interesting feature is the "hardness" of the neutron spectrum which is the maximum flux value of the spectrum. The University of Texas at Austin's facility has achieved an overall "harder" spectrum than that of the COMET and FFTF. Both (Greenwood et al., 2014) and the University of Texas at Austin's facilities have achieved approximately the same fast flux shape which can be attributed to the similar materials utilized. The only departure occurs at the further, epithermal regions, which is primarily a function of boron density thickness. The spectrum achieved by (Greenwood et al., 2014) was done through an enriched ^{10}B material thickness of 2 cm at approximately the same density as the facility at the University of Texas at Austin where the thickness of the powder used was ~ 1.08 cm.

EXPERIMENTAL: COMPUTATIONAL APPROACH, PART 2

MCNP Final Design: Material Formatting

The final design of the experiment excluded the use of silver, cut the amount of cadmium in half (thickness-wise) and adopted a separate canister for the enriched ^{10}B powder to reside. These changes were implemented to allow for as much enriched ^{10}B powder as possible between the sample and the bare reactor flux. These changes were the result of learning that the density being modelled was not the actual density of the boron powder as previously expected. The density was initially thought to be, untapped, 2.17 g cm^{-3} as this was the quote given by the manufacturer, 3M. Because it wasn't the theoretical density of elemental boron, 2.34 g cm^{-3}, it was figured to be correct.

Table 3: 3M data specification sheet for the enriched B powder.

Typical Physical Properties
(Not for specification purposes)

Properties	Crystalline ^{10}Boron
Enrichment	≥ to 96%
Molecular Weight	10.02 for 99% ^{10}B
Crystalline Structure	Beta Rhombohedral
Density	2.17 g/cm^3 for 99% ^{10}B
Thermal (n,α) Cross Section (Barns)	3837
Atomic Mass Number	10.01294

The enrichment should have been a red flag as natural boron has approximately 80% ^{11}B and 20% ^{10}B whereas this powder reversed those percentages and then some. Since ^{10}B is lighter than ^{11}B it should have been obvious at the time that the quoted density was the maximum theoretical density of the powder, supposing one can compress it to that value. The actual maximum tapped density for the powder, through trial and error in packing, is around 1.3-1.5 g cm^{-3}. This is a 30% reduction in the modelled boron content that was previously approximated and therefore resulted in the removal of silver (due to its ineffectiveness in the epithermal-fast region) and 1 out of the 2 cadmium sleeves. The inclusion of an Al canister was made if one wanted to retrieve the enriched powder from the system. This was implemented to also prevent the powder from getting wet and/or polluting the reactor water, if the system somehow broke open. The material makeup of the insert is again still made of aluminum 6061-T6. The ID/OD, tube length and total length of the 3-EL insert remain the same as previously noted.

The length of the Cd and ^{10}B layers were modelled to be comparable to the length of a fuel pin: 140 cm, where the ^{10}B layer length was controlled via the aluminum canister it was made to be compacted in. The length of the Cd sleeve was fixed to 58.52 cm (actual measured value) and the ^{10}B length was adjustable with a maximum volumetric occupancy of 666 cm^3.

Table 4: Measurements of the materials to be implemented into the 3-EL design.

Material	**Length (cm)**	**Inner Diameter (cm)**	**Outer Diameter (cm)**
3-EL Aluminum Tube	121.92	4.47	4.76
Cadmium Sleeve	58.52	4.27	4.37
Aluminum Canister	61.16	4.02	4.27
Enriched Boron-10 Powder	58.42	1.91	4.02
Aluminum Pneumatic System Piping	N/A	1.34	1.91
Quartz Glass Encapsulated Sample	10.16	0.98	1.18

The final design of the experiment implemented the chosen materials into a closed ended, cylindrical layered format, inside the 3-EL insert; Figure 26 on the following page represents the final design. It depicts the organization of each material and approximately how thick the filtering layers are relative to the total length of the pipe.

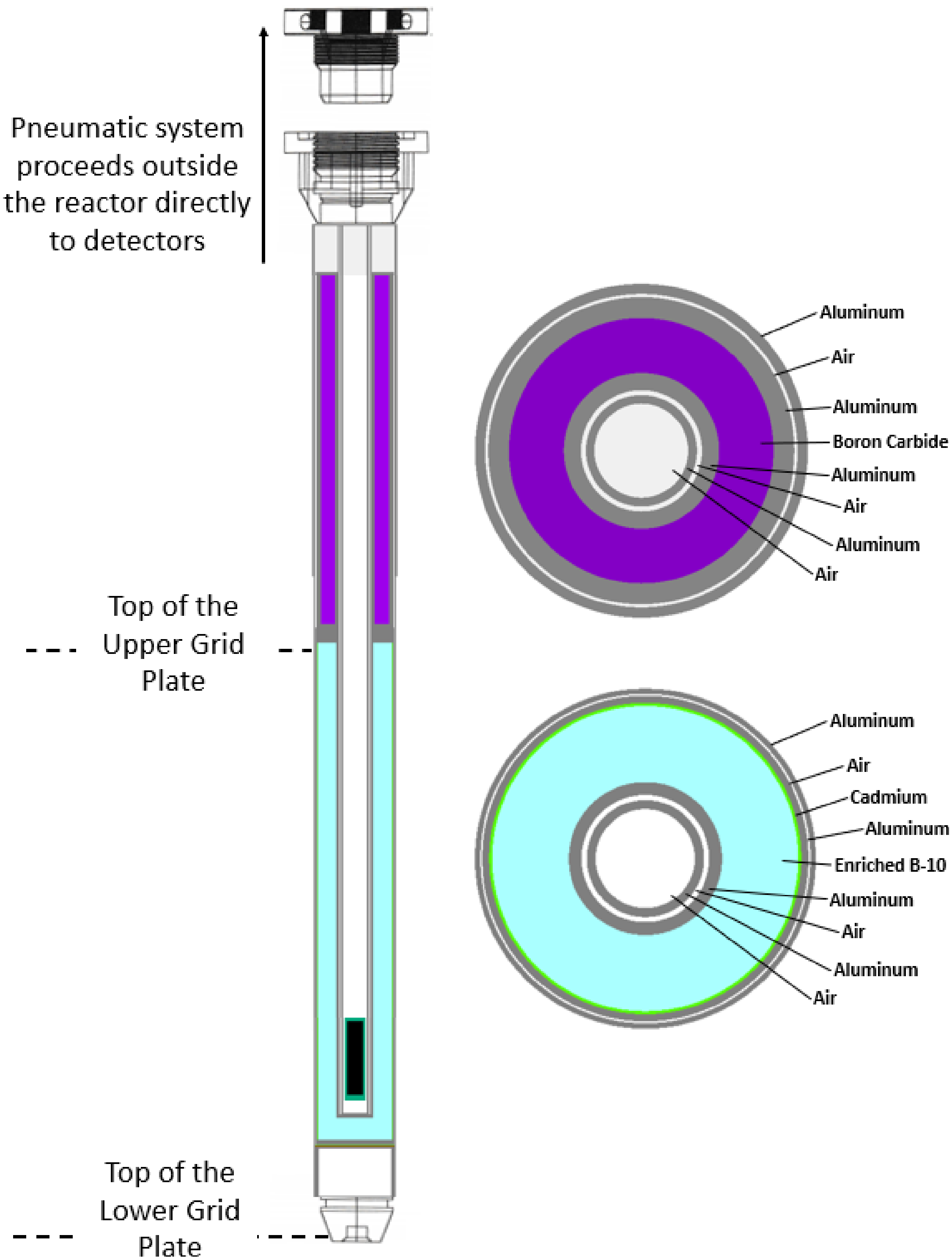

Figure 26: 2D schematic of the 3-EL insert and its constituents.

Let it be noted that two separate designs offering the same thickness of boron powder were proposed. These designs simply swap the dimensions of the Al and Cd ID/OD's while maintaining all other parameters as a constant (this is what was ultimately pushed for the final product). The MCNP results did not differ between the two models because this change preserved the radial thickness of boron powder between the sample and outside flux, thus retaining the same overall flux the sample sees. This allowed for the options of having the Cd sleeve on the inside or outside. The Cd was ultimately chosen to be on the inside for cleanliness in sliding the Al canister into the 3-EL insert.

The material makeup of this insert is Al 6061-T6. The size of the Al tubing is 4.468 cm inner diameter and 4.763 cm outer diameter. The length of the Al tube is 122.238 cm. The total length of the entire insert, tip to tip, is about 127.953 cm. As can be viewed from the schematic, there is also a boron carbide powder filled annulus above sample location which serves to minimize the number of thermal-epithermal neutrons that could enter the system and interact with the sample. The materials mentioned in Table 4 represent the middle-lower portion of the graphic. The upper portion is composed of boron carbide powder that fits in an Al 6061-T6 annulus that measures 52.070 cm in length. This material was chosen to be above the materials listed in Table 4 to further reduce any thermal neutrons that might interact with the sample during its transfer into and out of the reactor. The portion of the 3-EL insert that is within the reactor is the lower half. The reactor measures approximately 60.960 cm in height, from grid plate to grid plate, while the 3-EL measures 127.953 cm in length, as previously mentioned. The lower portion of the graphic is just a hollow Al 6061-T6 spacer of 3.810 cm in height. This was placed here to shift the sample to the height specified. In the Appendix is a SolidWorks model of the 3-EL and the internal components to yield a better visualization of the setup.

Figure 27 on the following page depicts the final design of the fast neutron irradiation facility as modelled in MCNP. This 2D model shows a slice view of the TRIGA reactor with the fast neutron irradiation facility being the blue colored pipe among the green colored ones (fuel rods).

In support of the experiment safety approval, the k-values of the system (and hence the reactivity changes) were modelled.

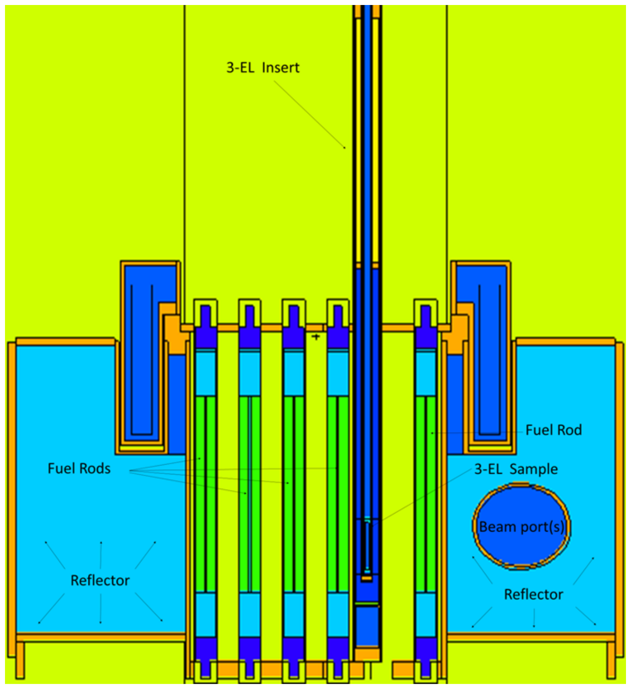

Figure 27: Vised 2D model of the 3-EL insert.

The resultant k-values were calculated using the following equation:

$$\rho = \frac{k_{eff2} - k_{eff1}}{k_{eff2} \cdot k_{eff1} \cdot \beta} \quad (10)$$

where k_{eff} is equal to the outputted value given by MCNP and β is taken as the delayed neutron fraction which is equal to 0.0067.

Table 5: Reactivity changes in the 3-EL.

3-EL Occupancy	Reactivity	(+/-) Error	Change in Reactivity ($)
With 3-EL Insert	1.05088	0.00062	-1.30000
Without 3-EL Insert	1.05959	0.00037	N/A
With 3-EL Insert & (107 g) Pu Sample	1.05109	0.00059	+0.03134

As before, the addition of a large amount of Pu into the reactor core would be a cautionary thing to do in the least. This was again tested to see how fast the neutron spectrum is relative to the fission and expected contribution to reactivity of Pu. The change in reactivity from adding this was only +$0.03134 (insertion of 3-EL into core resulted in a decrease of reactivity of about -$1.30000). As iterated in the previous section, if there existed a significant enough fraction of thermal neutrons entering the system, then we would have expected the addition of weapons grade Pu in the mg range to have made a much larger, positive reactivity change upon sample insert.

Final Design: MCNP & SCALE Results

The extensive modeling that was executed lead to the presented design in the previous section. The figures reflecting the resultant flux changes across the system as well as the number of fissions that occur are shown below. The goal of designing a filter to remove thermal and epithermal neutrons was achieved in this project under varying degrees according to the reader's definition of where a fast neutron is defined on the range of neutron energies (see Table 6). This facility was optimized for both the neutron spectrum and materials that were used. These parameters were weighted against the maximum size of the sample that could be allowed while maintaining an overall fast neutron spectrum (>95%).

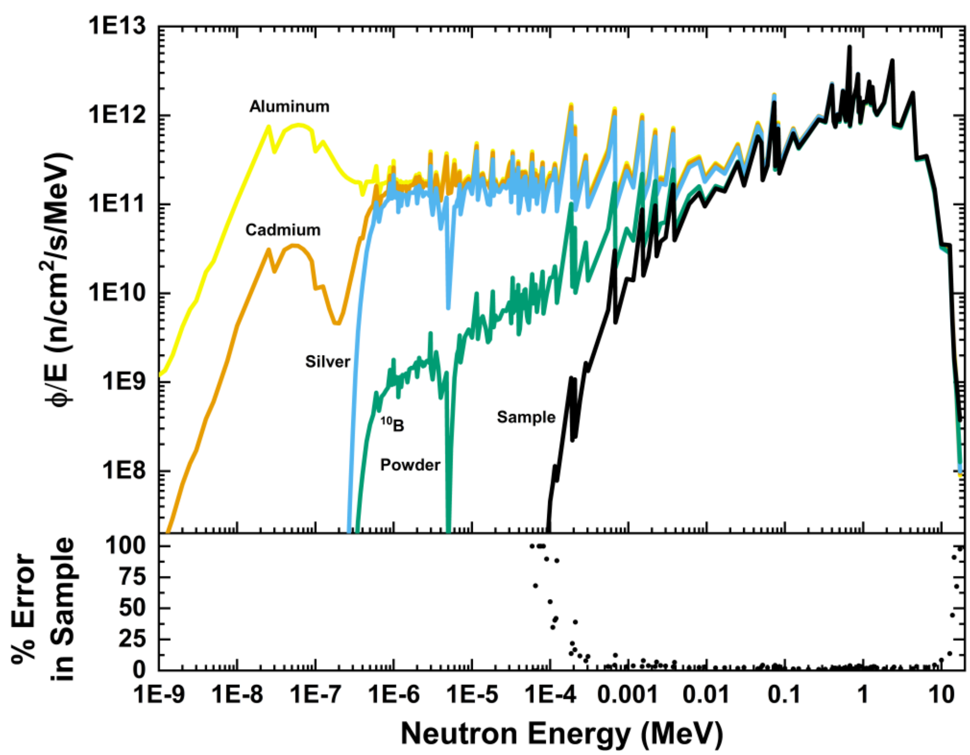

Figure 28: MCNP6 output showing the F4 tally progression through each material (with error in sample tally).

The tallies used in MCNP (F4 and MESH) outputted the neutron energy bins in a 238-group order so as to highlight the detail of nuclide cross sections. This is an important aspect of displaying the neutron spectra because it provides a more physically accurate depiction of the neutron energies that could be expected upon sample irradition. The MCNP model yielded a fast neutron flux value, defined $\geq 10^{-3}$ MeV, of 7.81×10^{11} n cm^{-2} s^{-1} in the sample position. Figure 28 shows the calculated neutron flux spectra after they interact with each layer in the 3-EL insert. The error in the neutron flux spectrum of the sample is displayed underneath these spectra to show the accuracy of the modeling across the calculated flux per energy bin.

The plot shown above depicts the finalized design's F4 tally output in MCNP after conversion to a lethargic plot. Underneath the main plot is a secondary plot of the error in the sample tally. The model was also made to show the characteristics of the isotopic neutron cross sections via the use of the 238-energy bin structure in order to better allow a software cross over of data to the SCALE platform to use in ORIGEN. This is because of the types of data ORIGEN or SCALE uses which are predetermined, collapsed neutron cross sections of a library of materials where one of those set groups happens to be the 238-group structure. The F4 tally was lethargically plotted as a function of the 3-EL layers of import such that the visualization of averaged fluxes incident on said layers is shown. Taking a step back, lethargy is defined as the natural log of the ratio of the maximum neutron energy, E_o, to the minimum neutron energy E (or rather upper and lower energy bin values, typically beginning from group 1, which is the maximum neutron energy defined in the problem (Duderstadt & Hamilton, 1976)):

$$\mathrm{Lethargy} = u = \ln\left(\frac{E_{upper}}{E_{lower}}\right) = \ln\left(\frac{E_o}{E}\right) \tag{11}$$

Differentiating the above leads to the relationship of lethargy to energy as:

$$du = \frac{-dE}{E} \tag{12}$$

From here we can make the approximation of small changes in lethargy to be written as:

$$\Delta u = u_1 - u_2 = \ln\left(\frac{E_2}{E_1}\right) \tag{13}$$

This is what the plot above shows. Its purpose is to show the spectral changes in energy of the neutron in exchange for giving up the absolute scale of the flux. This does not however mean that the data is invalid in determining the actual flux of the model, however, it will need to be reconverted back to its original F4 tally output form, undivided by the energy bin width. The fast neutron flux value was calculated from the F4 tally of the MCNP model to be 7.81 x 10^{11} n cm^{-2} s^{-1}. The fast neutron flux in this calculation was defined to be the region greater than or equal to 0.001 MeV which makes up for 99.71561% of the total flux.

Another interpretation of the calculated F4 tally data from MCNP would be to plot it as an FMESH tally. The differences are subtle yet may offer a more explicative representative of the absorption and shaping of the neutron flux as it flows through the 3-EL insert's materials. This tally was initiated at the front and back end of each material.

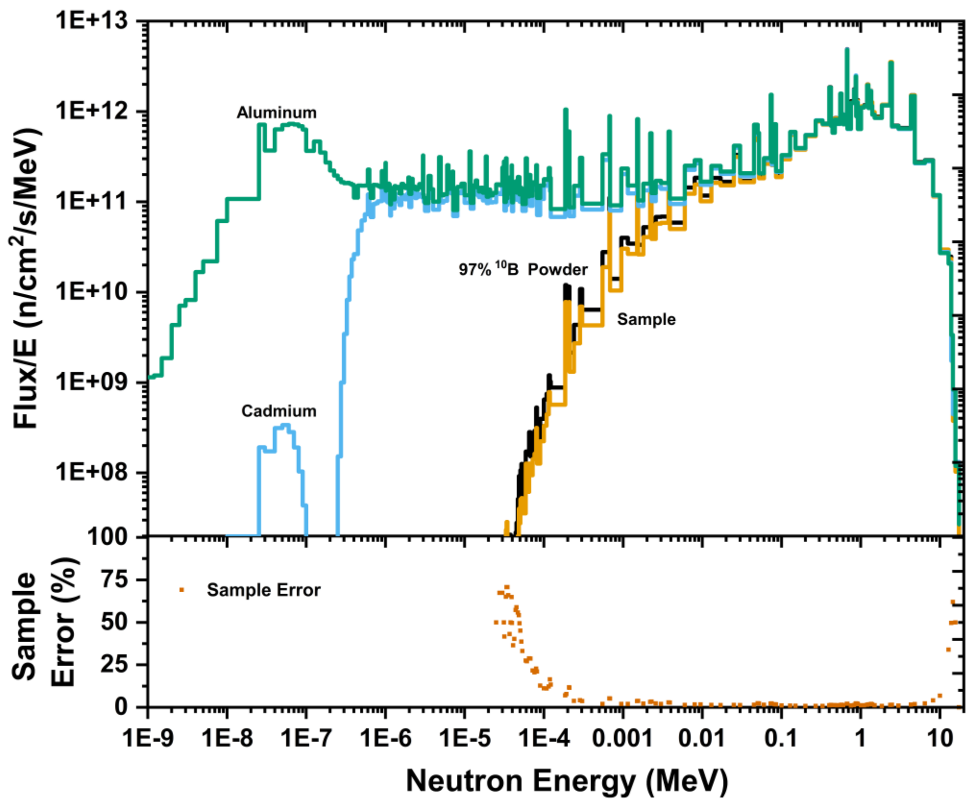

Figure 29: MCNP6 output showing the FMESH tally progression through each material (with error in sample tally).

The main differences can be seen in how the boron and cadmium layers are displayed spectrally on the lethargic plot. In Figure 28, the effect of the cross sections is more explicit as the F4 plot is averaged over the effect of the attenuation of neutrons over the entire volume of the material. Figure 29 reveals the total effect of the material on the flux. This figure is representative of the actual effect each material will have on the neutron flux. Contrary to interpretation, both figures are correct and analyzing the same region of the MCNP input deck. The total flux the sample encounters is the same. The following is a breakdown of the neutron flux into five energy groups:

Table 6: Five-group neutron energy breakdown of the MCNP flux calculation.

Neutron Energies (MeV)	**Flux, ϕ (n cm^2 s^{-1})**	**Percentage (%)**
10^{-9} MeV $\leq \phi \leq$ 25 MeV	7.84 x 10^{11}	100.0000
10^{-9} MeV $\leq \phi \leq 10^{-4}$ MeV	7.66 x 10^{5}	0.000098
10^{-4} MeV $\leq \phi \leq$ 0.001 MeV	2.23 x 10^{9}	0.284293
0.001 MeV $\leq \phi \leq$ 0.01 MeV	3.95 x 10^{10}	5.042187
0.01 MeV $\leq \phi \leq$ 0.1 MeV	1.04 x 10^{11}	13.26140
0.1 MeV $\leq \phi \leq$ 25 MeV	6.38 x 10^{11}	81.41202

Table 6 demonstrates the neutron flux predicted at the sample, separated into 5 neutron energy groups. In this table, the overall distribution of the flux is shown per energy group to address differences in the interpretation of a fast neutron. The definition imposed in this work would show that the fast neutrons populate 99.71561% of the total neutron flux.

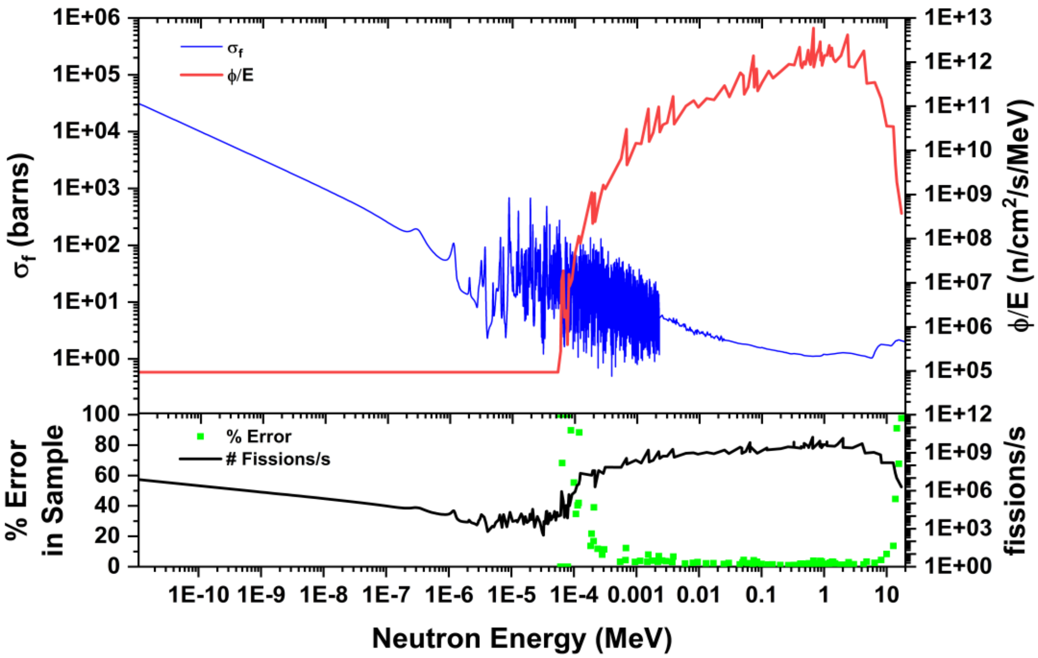

Figure 30: Fast flux output with an approximated epithermal-thermal neutron spectrum (blue) plotted with the ^{235}U fission cross section (red). The estimated number of fissions (black) is shown below those figures with error values (green) taken from the MCNP6 output.

Now, the goal of Figure 30 is to illustrate the relationship between the number of fissions that occur per unit energy. A correlation is made between this and the flux over the SCALE irradiation of a 10 mg mass of ^{235}U. The fission cross section of this nuclide is also plotted on the same energy scale to show the large differences in the probability of a fission occurring within that energy range. Because the fissions at thermal energies are approximately 10^5 times more likely to occur, the fast neutron flux must be at least 10^5 times greater than the overall thermal flux to exhibit any comparability in the number of fissions that occur per incident neutron interaction. To clear up any confusion, let it be noted that the flux was assumed to be constant from 10^{-5} MeV to 10^{-11} MeV (in the flux figure, blue). This was done due to the inefficiency of the computational equipment such that a runtime for a model to attain the values at those energies would be horrendously long. Therefore, a worst-case scenario was assumed where the flux was made to remain constant over the thermal region rather than *non-existent* in order to provide a comparison of the fast neutron induced fission vs. the thermal/epithermal neutron induced fissions. It may have been noted that if the said region was to have been made constant, why the figure fails to reflect this? The flux value that is plotted (blue) is a flux per unit energy spectrum, meaning that the flux from the F4 tally that was outputted was divided by the energy bin width to better reflect the neutronics of the system as it pertains to lethargy. And because the energy bins in the 238-group neutron energy structure are not the same, what is shown in Figures 27 and 28 are the result.

The expected fission rate ratio of the fast ($\geq 10^{-3}$ MeV) to epithermal/thermal induced fissions was calculated to be > 100 to 1 where the total fast fissions in the defined energy range were tallied to be 4.30×10^{7} fissions per second.

The MCNP reactor geometry was also compared against the SCALE KENO-VI model for differences in criticality and more importantly this depletion model provided the means for the "depletion" or irradiation of about 109 g ^{239}Pu to determine fission product generation data. The geometries of both reactor models can be seen below:

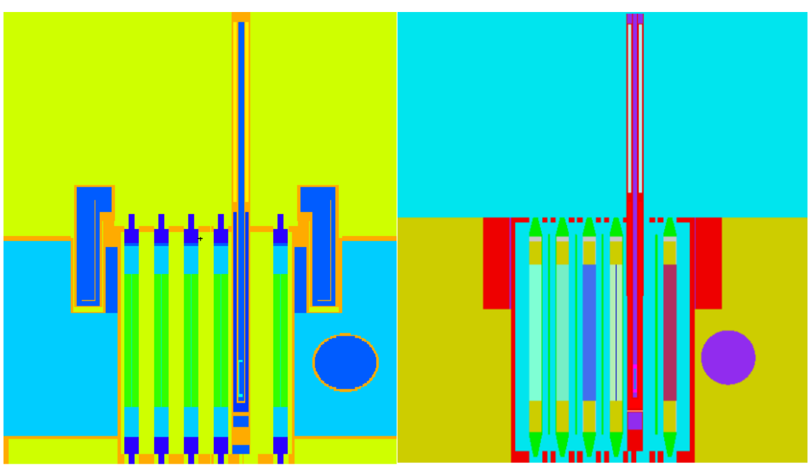

Figure 31: MCNP (left) reactor geometry comparison to SCALE (right) reactor geometry.

The reactor model used in SCALE is a more realistic representation of the TRIGA Mark-II reactor than that represented in MCNP. This is because the SCALE model was built utilizing each of the 87 individual fuel element isotopics that were first acquired when the reactor was moved to the Pickle Research Campus [correspondence with Mike Whaley].

Table 7: Reactivity comparisons across the two reactor models.

OCCUPANCY OF THE 3-EL FACILITY	MCNP6 (~109 g Pu)			SCALE KENO-VI (~109 g Pu)		
	Reactivity (ρ)	Error (+/-)	Change in Reactivity (Δρ)	Reactivity (ρ)	Error (+/-)	Change in Reactivity (Δρ)
With 3-EL Insert	1.05088	0.00062	-1.30000	1.00190	0.00031	-1.20149
Without 3-EL Insert	1.05959	0.00037	N/A	1.00995	0.00042	N/A
With 3-EL + Pu	1.05109	0.00059	+0.03134	1.00172	0.00023	+0.02687

The difference in the reactivity norms for each model can partly be attributed to the specifications made for the respective fuel compositions. One model (SCALE) was created with burnup calculations in mind where the composition of fuel is of great import whereas the other was created for an exact likeness of the TRIGA reactor and its beam ports resulting in less care for the composition of individual fuel elements (all created to be the same). Because of the location of certain fuel elements which may or may not be vastly different in their attribution to reactivity, it would make sense that the models do not exactly line up. The response of each model is well within reason of one another via the insertion of the 3-EL and a large amount of Pu into the reactor model. The fidelity of the KENO-VI model was initially noticed to be is missing a significant digit in the overall k-effective value. This was projected to be due to the NPS ran per burnup cycle as with larger NPS values it was found that the precision of the k-effective values increased by a factor of 10.

The SCALE model's output (.f71 format) was then analyzed against a COUPLE—ORIGEN module for the fission products ^{99}Mo and ^{140}Ba as they are commonly known to remain constant over time during fission (due to their favorable nuclear constituents as fission products). The COUPLE—ORIGEN module consists of importing an F4 tally from

MCNP and converting it to a usable source of radiation (.f33 format) via the COUPLE module in SCALE. This is then able to be utilized in the ORIGEN module where one can perform simple irradiation and decay programs on any sort of material, in this case, Pu.

Furthermore, ORIGEN allows the input of the total flux value that one is irradiating a sample with. This is highly useful such that we approximated the total flux from the F4 tally output in MCNP. This value was imported into the ORIGEN module and used as a gauge to adjust the power utilized in the KENO-VI reactor model shown prior. This is important because the KENO-VI model handles power in units of MW/MTU, which is sort of unknown to us at this point but was estimated given the starting fuel elements initial values and running models of varying power levels to thus match the outputs from KENO-VI to ORIGEN (this turned out to be approximately 12 MW/MTU or “W/g”). The overall flux seen in the sample area can be viewed in the following snippet from the output file. This file details how each component attributes to the power of the reactor. It also details how much of the flux in each specific mixture is a thermal flux (defined via the 0.625 eV cutoff or Groups 200-238) compared to the total cumulative flux per mixture.

Mixture Number	Total Power (MW/MTIHM)	Fractional Power (---)	Mixture Power (MW/MTIHM)	Mixture Thermal Flux n/(cm^2*sec)	Mixture Total Flux n/(cm^2*sec)
1	0.001	0.00010	N/A	1.8705e+12	6.9477e+12
2	0.038	0.00310	N/A	1.7298e+11	3.9378e+11
3	0.097	0.00786	N/A	7.6844e+11	2.1656e+12
4	0.004	0.00032	N/A	5.2631e+11	9.0399e+11
5	0.015	0.00119	N/A	7.1924e+11	1.5178e+12
6	0.000	0.00001	N/A	7.4563e+11	1.5312e+12
7	0.010	0.00084	N/A	5.5893e+09	2.0290e+12
8	0.000	0.00000	N/A	3.1052e+12	1.1178e+13
9	0.001	0.00011	N/A	1.6601e+12	4.4790e+12
11	0.004	0.00034	N/A	2.5150e+10	1.0342e+12
12	0.000	0.00001	N/A	5.7516e+10	2.3535e+11
13	0.003	0.00025	N/A	7.5516e+07	8.6642e+11
14	0.000	0.00000	N/A	0.0000e+00	6.1930e+11
15	0.000	0.00000	0.221	0.0000e+00	1.4493e+12
16	0.000	0.00000	N/A	5.5920e+07	3.1084e+09
2899	0.158	0.01284	19.136	3.0703e+12	1.0094e+13
2902	0.063	0.00513	7.037	1.1070e+12	3.9732e+12
2903	0.073	0.00596	7.961	1.2475e+12	4.3242e+12
2904	0.059	0.00477	5.968	9.3188e+11	3.0328e+12
2905	0.136	0.01103	15.549	2.5097e+12	8.9115e+12
2906	0.141	0.01145	16.334	2.6312e+12	9.3647e+12
2908	0.085	0.00692	9.191	1.4412e+12	5.0239e+12
2910	0.129	0.01043	15.041	2.4041e+12	8.5990e+12
2911	0.111	0.00897	12.408	1.9486e+12	6.5507e+12

Figure 32: Snippet of SCALE-KENO-VI output detailing flux relative to power.

The total flux that is calculated to be passing through mixture 15, our Pu sample, is only 15% larger than that found in MCNP. This gives more confidence in the solutions acquired for the fission products that are generated in the KENO-VI reactor model as compared to the COUPLE-ORIGEN module output. The output of the KENO-VI module can be seen below for an irradiation of 109 g Pu for 10 seconds and decay of 10 minutes. The concentrations of ^{239}Pu between COUPLE-ORIGEN and KENO-VI were made to precisely the same where the initial enrichment defined in MCNP was along the 93.5% scale (weapons grade). It will be briefly noted that during the use of the KENO-VI model, it was discovered that because the TRIGA reactor heavy metal contents are well below 1,000,000 grams, the software normalizes all heavy metals to that singular value. So, during the process of modelling, values were constantly much higher than expected until the normalization factor was discovered, which was quantified to be 46.927 for the system.

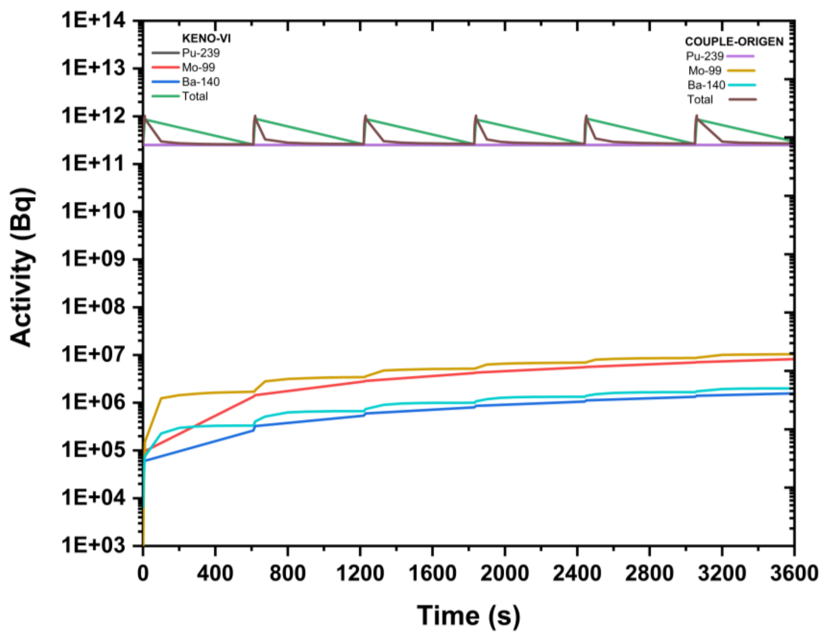

Figure 33: SCALE outputs of the KENO-VI and COUPLE-ORIGEN irradiations of Pu.

The figure shown above illustrate the outputs generated by KENO-VI and COUPLE-ORIGEN modules. The KENO-VI model does not utilize any MCNP flux data while the COUPLE module implements the MCNP flux data into a format usable by

ORIGEN. Each model was used to perform the irradiation of the same amount of Pu where the power in the KENO-VI model was adjusted to better align the output fission product data of the isotopes ^{140}Ba and ^{99}Mo. The above models both performed 10 second irradiations and 10-minute decays where the nuclides were normalized to one another. The COUPLE-ORIGEN module was then used to determine the expected total activities for a 10 mg ^{239}Pu sample under irradiation/decay schemes. This value was calculated to be 2.5 mCi or 94.97 MBq which was determined to be well below any safety issues that may occur during sample transfer (workers) and/or counting (detector).

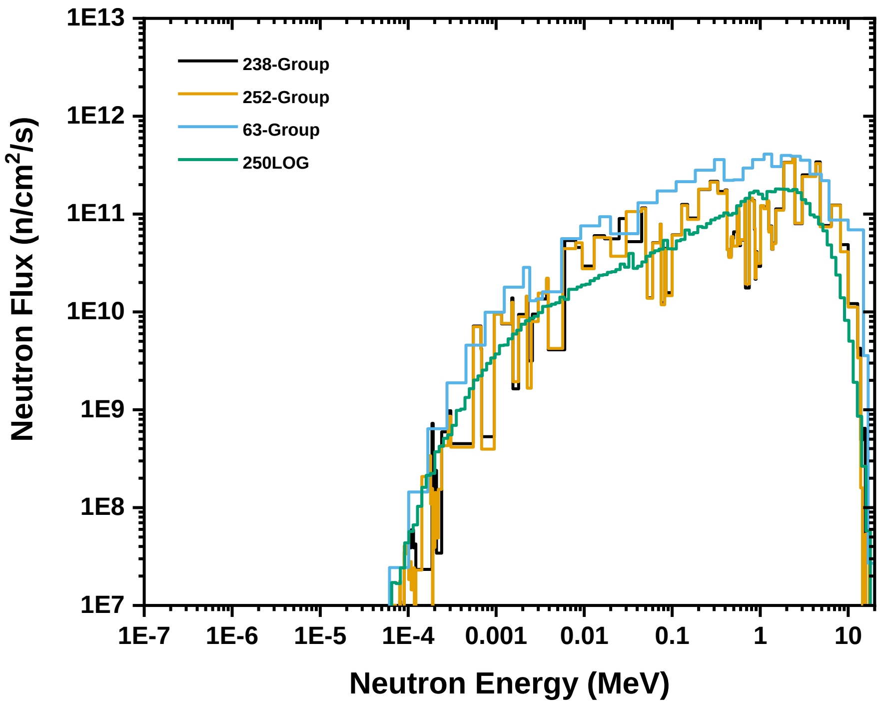

Figure 34: Comparison of the same model outputted using various neutron energy bins.

As an aside, through researching various papers on the subject of fast neutrons or simply flux shaping, it was discovered that there was a lack of use in plotting the data using the same energy bin structures that various neutron cross sections are plotted in such as the collapsed 238-group or the relatively new 252-group. That does not imply that the data being depicted in other plots is incorrect however, rather, it is more so thought to be less detailed and indicative of what to expect. Looking at the Figure above one can see various details that are lost in the model, when comparing the CINDER ’63 energy bin spacing to the 238 or 252 energy bins spacing; especially in the areas centered around 0.1 and 1 MeV. These features that are lost are cross section effects from the Al content within the model. Another thing to note, if unknown, is the reduction in the overall flux output as there is an increase in energy bins. This is due to the finer division of the overall flux as it pertains to energy bin spacing, thus decreasing the general magnitude shown. To renormalize the figures, one would need to divide each by their respective energy bin widths. Comparing Figure 24 (from previous section) to Figure 29 once can also note a magnitude of differences and detail lost in their respective fluxes.

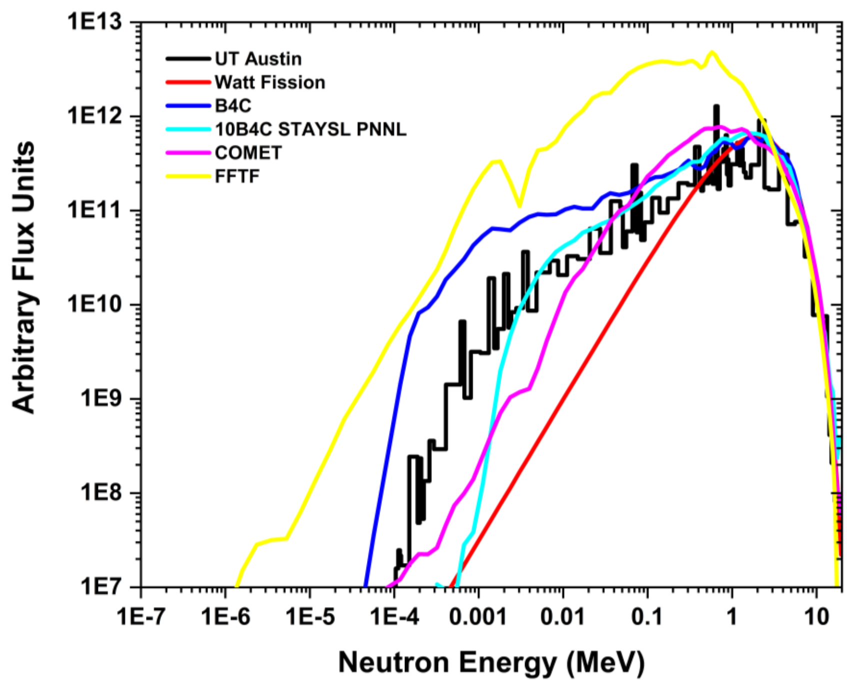

Figure 35: Comparison of the fast neutron, 3-EL insert to various fast neutron facilities (Greenwood et al., 2014).

The flux in Figure 35 is compared against various known fast flux facilities that have existed over the years. The data for this figure was taken from (Greenwood et al., 2014) as before and therefore, the features do not reflect magnitude in flux values. The change in flux shape is indicative of the neutron energies of interest in neutron activation analysis. With that made clear, it can be seen that both the facilities here at the University of Texas at Austin and Washington State University (Greenwood et al., 2014) have achieved a near identical fast flux shape ($\geq 10^{-3}$ MeV). The flux profiles then appear to diverge once the neutron energies get closer towards the epithermal neutron range. The cause of this diversion is due to the differences in density of ^{10}B atoms and overall "radial thickness" of said isotope. The spectrum that was achieved by (Greenwood et al., 2014) was with a boron material thickness of 2 cm at approximately 1.35 time the density than that of the ^{10}B powder used in the 3-EL facility. In addition, the boron material thickness used in the 3-EL facility at this reduced density is on the order of ≈1.00 cm. The following figure shows the various 3-EL configurations of materials.

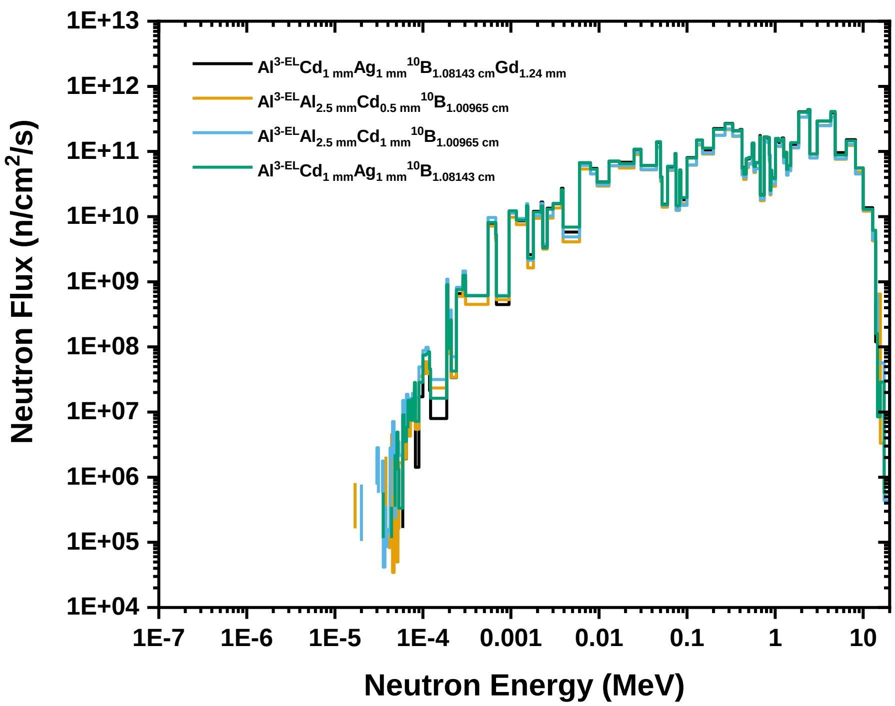

Figure 36: Comparison of the 3-EL insert using various material configurations.

This figure shows the ever so slight differences achieved in the output spectrum when ordering the materials in a variety of formats. The inclusion of this figure serves to present to the reader all the varied configurations that were attempted before finalizing on the 2nd (orange) spectrum on Figure 36. The limitations of this facility are really dictated by the amount of ^{10}B per unit volume that can be placed between the sample and overall flux. There are hardly any differences in these different layering designs precisely because the boron content is nearly unchanged.

Overall, the advantage of the 3-EL facility will be the present construction of a pneumatic/rabbit system for sample transfer into the 3-EL irradiation facility. Once complete, this facility will be capable of remote sample setup, irradiations and data collection of mg quantities of ^{238}U, ^{235}U and ^{239}Pu rich samples.

Final Design: Helium Buildup

The by-product of the absorption of neutrons by ^{10}B is a $^{7}Li^{+}$ and an α particle. When there is a significant amount of ^{10}B in a system, the generation of He becomes a very real problem because absent the proper pressure release valves, a rupture in the containing structure could occur. Therefore, an F4 tally and a tally multiplier for the (n,α) reactions were used to determine the total number of He atoms produced per second in the canister containing ^{10}B powder. The free volume inside the 3-EL was approximated to be 0.4 L through density deficit calculations performed on the measured and theoretical densities of the powder. The production of He was assumed to begin in a complete vacuum with 0.4 L capacity. The temperature was estimated as the maximum temperature in the system, 427K. These assumptions showed that to attain a pressure of 760 torr or 1 atm, the reactor will have to have been operating at full power for about 29,000 days. This approximation shows that there is expected to be a slow buildup of He gas vs. time but nothing significant enough to give pause for concern. With the inclusion of a pressure relief valve, the buildup of He is not expected to present an issue in this system.

Final Design: Conclusions

The fast neutron irradiation facility that has been extensively modelled above has shown enough promise in design that it has been in the process of being built since January 2018. Through comparisons against other fast neutron facilities spectra, the facility at the University of Texas at Austin has been shown to be a contributor in the field of fast irradiation's, primarily due to the addition of a pneumatic system for faster sample transfer and analysis. The facilitation of such an experiment will be quite simple as it takes place within a pre-existing irradiation facility. The 3-EL fast neutron irradiation insert is already built and is in the process of attaining characteristic flux spectra as well as thermal readings for sample heating. These tests are to be done in a semi-auto fashion such that the tubes of the pneumatic facility will be used to feed in, via a wire or string, the flux wires and/or thermocouples to attain the desired data. PNNL-STAYSL software will be used in the future to extract the neutron flux from the activated flux wires. The acquired data will then be published in a future paper and the following dissertation to this thesis.

HEAT TRANSFER CALCULATIONS

2D Modelling, *Microsoft Excel* Analysis

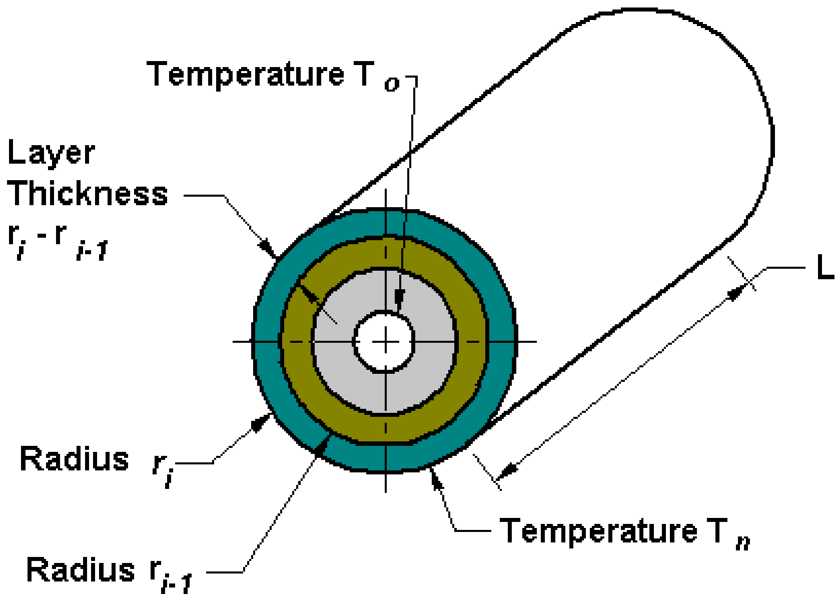

Figure 37: Example heat transfer calculation method used.

Figure 37 utilizes the following heat transfer equation:

$$T_o = T_n + \frac{\Delta q}{2 \cdot \pi \cdot L} \cdot \left(\sum_{i=1}^{n} \frac{1}{r_o h_o} + \frac{\ln\left(\frac{r_i}{r_{i-1}}\right)}{k_i} + \frac{1}{r_n h_n} \right) \tag{14}$$

where T_o is the inner surface temperature (°C), T_n is the outer surface temperature (°C), q is the heat flow from T_o to T_n, r_i is the outer radius of the layer i (cm), r_{i-1} is the inner radius of the layer i (cm), k_i is the thermal conductivity of layer i (W cm^{-1} °C^{-1}), h_o is the heat transfer coefficient of air (W cm^{-2} K^{-1}), h_n is the heat transfer coefficient of water (W cm^{-2} K^{-1}), r_n is the radius of water layer (cm) and L is the length of the cylinder (cm). This equation was used as a decent approximation for the first principles determination of what the temperature inside the 3-EL facility will be. The data used in the above calculation can be found in the following table:

Table 8: Values extracted from MCNP for heat transfer calculations (excluding thermal conductivities).

Cells	Material	Density (g/cc)	Volume (cc)	Mass (g)	Heating (MeV/g/source particle/s)	Watts Heat Generated (W)	THERMAL CONDUCTIVITY, (W/K cm)
796	Al	2.700E+00	3.160E+01	8.531E+01	1.773E-07	1.689E-01	1.520E+00
797	Cd	8.650E+00	4.067E+01	3.518E+02	1.506E-04	5.915E+02	9.700E-01
799	Al	2.700E+00	6.792E+02	1.834E+03	3.143E-09	6.437E-02	1.520E+00
800	Al	2.700E+00	1.311E+02	3.541E+02	9.339E-08	3.692E-01	1.520E+00
801	Air	1.205E-03	1.266E+02	1.526E-01	7.547E-07	1.286E-03	2.400E-04
696	Al	2.700E+00	2.033E+02	5.488E+02	6.577E-10	4.030E-03	1.520E+00
699	B4C	1.460E+00	3.833E+02	5.596E+02	1.555E-07	9.715E-01	1.626E-03
700	Al	2.700E+00	5.373E+01	1.451E+02	4.663E-10	7.554E-04	1.520E+00
701	Al	2.700E+00	5.615E+01	1.516E+02	9.371E-08	1.586E-01	1.520E+00
702	Air	1.205E-03	3.976E+01	4.791E-02	4.267E-07	2.283E-04	2.400E-04
703	Al	2.700E+00	6.283E+01	1.696E+02	9.406E-08	1.782E-01	1.520E+00
704	Air	1.205E-03	1.436E+02	1.731E-01	3.654E-07	7.063E-04	2.400E-04
705	Quartz	2.203E+00	5.385E+00	1.186E+01	5.399E-07	7.153E-02	1.460E+02
706	Air	1.205E-05	5.726E+00	6.899E-05	1.311E-06	1.010E-06	2.400E-04
707	Al	2.700E+00	1.038E+02	2.804E+02	1.173E-07	3.672E-01	1.520E+00
708	B-10	1.550E+00	2.118E+02	3.284E+02	6.682E-06	2.450E+01	1.626E-03
709	B-10	1.550E+00	3.503E+02	5.430E+02	3.283E-05	1.991E+02	1.626E-03
710	Ag	1.049E+01	1.568E+00	1.645E+01	1.323E-08	2.430E-03	4.060E+00
711	Cd	8.650E+00	1.568E+00	1.356E+01	1.176E-04	1.781E+01	9.700E-01
712	Al	2.700E+00	1.580E+01	4.266E+01	9.662E-08	4.603E-02	1.520E+00
713	Air	1.205E-03	3.899E+01	4.698E-02	1.390E-06	7.290E-04	2.400E-04
714	Al	2.700E+00	7.964E+01	2.150E+02	5.524E-08	1.326E-01	1.520E+00

The progression of the calculations performed in the above table proceed as follows:

$$Q(\mathrm{W}) = F6_{\mathrm{Tally}}\left(\frac{\mathrm{MeV}}{\mathrm{g \cdot SP \cdot s}}\right) \cdot \mathrm{SP} \cdot 1.60218 \cdot 10^{-13}\,\frac{\mathrm{J}}{\mathrm{MeV}} \cdot \frac{1\,\mathrm{W \cdot s}}{\mathrm{J}} \cdot \rho\left(\frac{\mathrm{g}}{\mathrm{cc}}\right) \cdot V(\mathrm{cc}) \tag{15}$$

where SP is defined as the number of source particles in the problem, approximated to be 6.97E16 for the entire reactor geometry. The temperature inside the fast neutron 3-EL was determined to be 149 ^{o}C. This value was calculated through the tailoring of previously acquired experimental data where the temperature inside a Cd-lined PNT was found to be approximately 120 ^{o}C at 950 kW. The tailoring involved the determination of the cooling done on the Cd-lined PNT relative to the 3-EL which was found to be about 775 W of heat removal. The heat that was generated in each material was found through energy deposition calculations using MCNP.

Between the heating resulting from the (n,γ) and (n,α) reactions of boron and cadmium, cadmium is the more major contender in heat generated primarily because it is absorbing the largest part of the incident spectrum being the thermal neutrons. The boron powder creates about ¼ the amount of heat Cd generates but local energy deposition and lack of excellent heat transfer properties mean that it will take longer for this heat to leave the material. Therefore, these materials are the main attributors to heating in the 3-EL.

2D Finite Element Modelling, *QuickField* Analysis

Additional heat transfer calculations were performed using the FEA software QuickField. This software was used to perform a transient to steady state analysis of heating in the system using the F6 tally data generated in MCNP. It offered a more robust prediction of the way in which heat would be stored in the system and visually depicted the expected result of boron insulating most of this heat in the system.

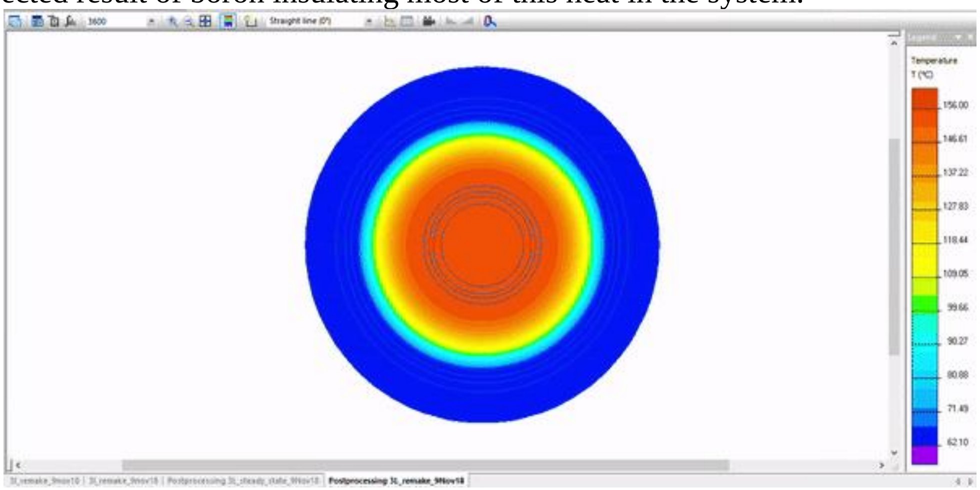

Figure 38: Transient heat transfer approach to steady state temperature in 1 hour.

It will be noted that because the software was available for only a temporary time period, the model shown above differs in: boron density (2.17 g cm^{-3}), a Ag layer (1mm) and a layer of Cd that is 1 mm (compared to current 0.5 mm). This analysis yielded a final temperature for the interior of the system to be approximately 156°C after approximately 1 hour of transient heating. This is in close relation to the calculation done in the Excel analysis probably because the boron, although less dense in the previous situation, still retains most of the heat due to its low thermal conductivity value (Stein, 1954). This agreement gives confidence in the values calculated but will be further verification in SolidWorks using an exact 3D model of the components that are to be placed into the reactor core will be done to solidify and remove any concerns of heating the system during its occupancy in the reactor.

3D Finite Element Modelling, *SolidWorks Flow* Analysis

The purpose of performing the heating analysis in SolidWorks was to further verify and subdue any concerns in heating of the 3-EL insert. The limiting factor in the heating of the 3-EL comes down to the melting point of cadmium, being 321^{o}C. This is followed by the melting point of aluminum which comes in at around 600^{o}C. So, the overall goal of this analysis is to alleviate any concern of the cadmium material coming close melting inside the 3-EL. In the Appendix exists the report generated by SolidWorks for the following Figure of the heat distributed throughout the 3-EL.

The output by SolidWorks Flow Simulations depicts the relative temperature distribution in the 3-EL at steady state of a reactor power of 950 kW. The peak temperature that was yielded was about 427 K or 154^{o}C. The SolidWorks Flow Simulation utilized nearly all the same values as that of Table 5, except for built in tables for the change of: specific heat, thermal conductivity, and emissivity vs temperature. There was another major difference in this software compared to all other methods used which was its ability to roughly model the flow of the reactor pool where values from Alex Brand's Dissertation were used for the definition of the channel flow velocity (~0.2 m s^{-1}) and temperature (~323 K). Instead of guessing the cooling and extrapolating that to the 3-EL system, the forced convective cooling was approximated using this simulation by giving it the approximate channel area and flow that the 3-EL would currently encounter.

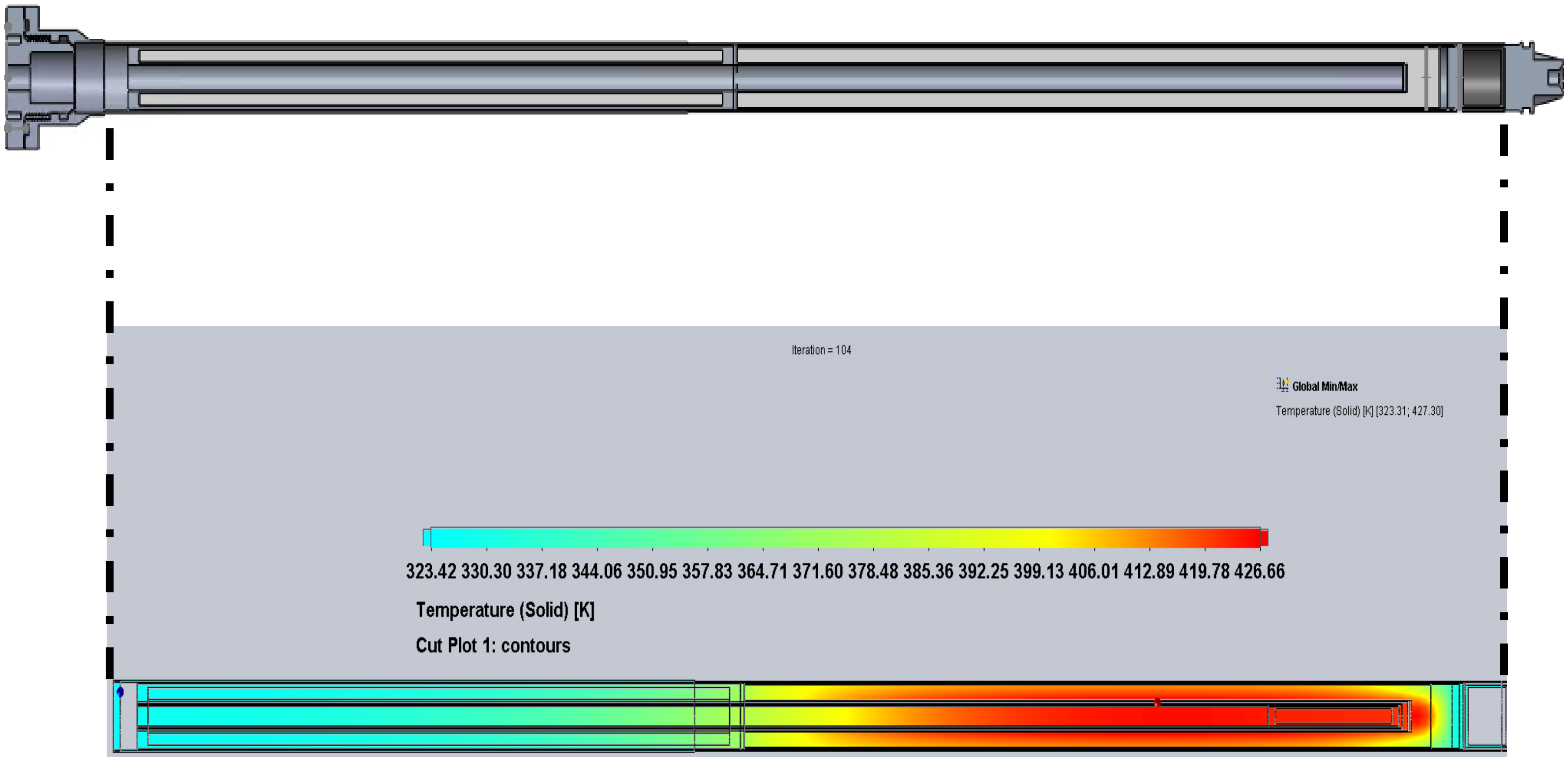

Figure 39: Results output of the heat distribution in the 3-EL at steady state.

The heat transfer coefficient used for the coolant was varied between 100-5000 W/m^2K where the heat removal from the system resulted in only a 3-7 K temperature change, internally. The results from this are in strong agreement with the other heat transfer calculations implemented where only a 2-7^oC difference was noted between all three different calculations. In the Appendix one can find the results document for both this Flow simulation and an earlier simulation done using the general Thermal Analysis executable offered by the SolidWorks software. The earlier one however could not achieve as consistent of results as the above due to trouble programming in the values per each material. The Flow Simulation offered a more intuitive and real-world approximation which was very helpful in achieving more meaningful results for the system as it allowed for built in tables defining thermal conductivity, specific heat, etc. whereas the other explicitly did not. It will also be said to mind the names given to certain materials and items (some were not named to be intuitive as to what they represent, I apologize in advance).

PNEUMATIC SYSTEM

Design

The design of the pneumatic system for the fast neutron facility was adopted from the design currently present for means of thermal/epithermal neutron activation analysis. That facility utilizes either a Pb-lined or a Cd-lined irradiation facility where a LDPE sample is pneumatically transferred. The facility for this work will utilize a sample that is twice as long, half as thick and more breakable as compared to the samples in use in the other pneumatic system. This means that the radius of curvature of piping for sample transfer will need to be larger in order to accommodate a longer sample size. This value was calculated to be 32” to accommodate a 4.5” sample.

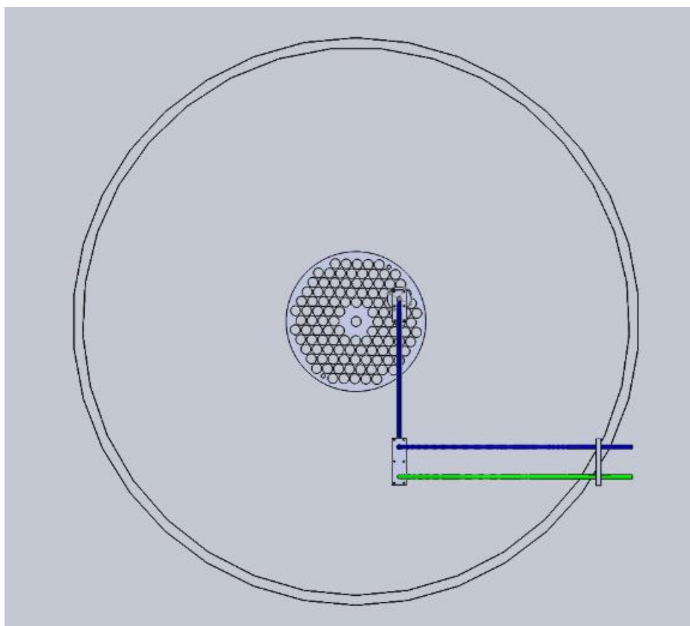

Figure 40: SolidWorks 3D schematic of the reactor core, 3-EL and pneumatic system.

Since the sample vials for the fast facility will be composed of quartz glass, they are more brittle and susceptible to fracturing and cracking and therefore cannot be slammed into and out of the core for safety reasons. This means that more careful consideration must be made in the programming of the pneumatic transfer system where compressive air resistance and flow could play a significant role in the safety of the sample. There has been some consideration for the use of Teflon which would mitigate this concern. Due to the large activation of ^{19}F at fast neutron energies, it will not be the main choice for sample containers.

Choice of Sample Transfer Containers

The container in which the sample is to reside was finalized to two materials: quartz and Teflon. Both materials were chosen because of their relative transparency to fast neutrons and their ability to withstand high temperature environments. Transparency does not mean that they do not interact with the fast neutrons. It means that they have been modelled to show that they do not affect the overall spectrum the sample sees. As described in the former section, Teflon will become activated once irradiated. The same can be said for quartz. But because the quartz being used it to be ultra-pure, this will effect be minimized and/or predictable on a gamma spectrum. Since quartz is the more brittle material of the two, the pneumatic system was designed for the optimization of safely transferring a quartz vial quickly to and from the reactor core. The sample size of choice, dictated by the maximum radial bend allowed via the design of the pneumatic system (see section above), was made to be 4.5 inches.

Acknowledgements of Assistance in Engineering the System

The facility could not be built without the help of Reactor Manager, Larry Hall, Electronics Technician, Jim Terry, Laboratory Technician, Mark Andrews, Health Physicist, Tracy Tipping, undergraduate researcher, Jesse Reisner, CEM machinist, John Nodler, and the many other undergraduate students who worked on the design and electronics of the facility.

BUILDING THE 3-ELEMENT INSERT

3-EL Insert: Modifications and Material Implementation

The design of the Al 6061-T6 3-EL irradiation container as shown below:

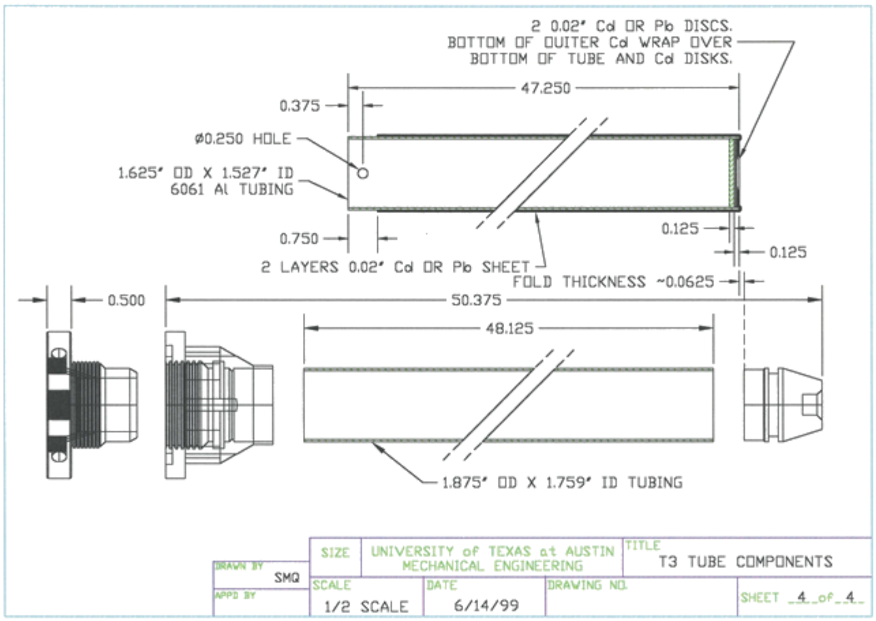

Figure 41: Schematic of the 3-EL insert absent internal neutron attenuating materials.

There have been no modifications to the original design of the 3-EL as shown in the above schematic. The 3-EL insert along with its designated facility were utilized to contain the fast neutron irradiation facility materials as well as house the pneumatic system for sample transfer. This was done through modification of the screw cap to have a pass-through hole which is then designated to be welded after the pneumatic system is inserted to the depth needed. The exterior of the 3-EL was also turned down on the lower 30” from 1.875” to 1.817” to address fitting issues had with other existing 3-EL inserts.

The fast neutron components inside the 3-EL insert have undergone multiple changes in the placement and order of the neutron attenuating materials. Initially, the design to be utilized consisted of filling the 3-EL with: an Al-spacer to provide an adjustment of sample height, Cd/Ag sleeves and disks to create a loosely fixed tube that would provide structure for the enriched boron powder to be packed in and an Al pneumatic sleeve to separate the pneumatic system from the freely packed 97% enriched ^{10}B powder. Then above this, would exist a naturally enriched B powder annulus where the containment is composed of Al 6061-T6. The Al-spacer's dimensions were changed on occasion (from 9" to 5" to 1.5") to adjust the sample to the height which in the reactor core which provided the maximum flux. Because there was uncertainty in the height that would produce a value of maximum flux, an experiment was performed to determine the exact height, the details of which can be found in the following section of this Thesis.

It was unfortunately found that the density of the 97% enriched ^{10}B powder was overestimated during modelling (due to an error in interpretation on a specifications sheet) during the building of the system. This information was subsequently corrected in the models specified in the Final Results section.

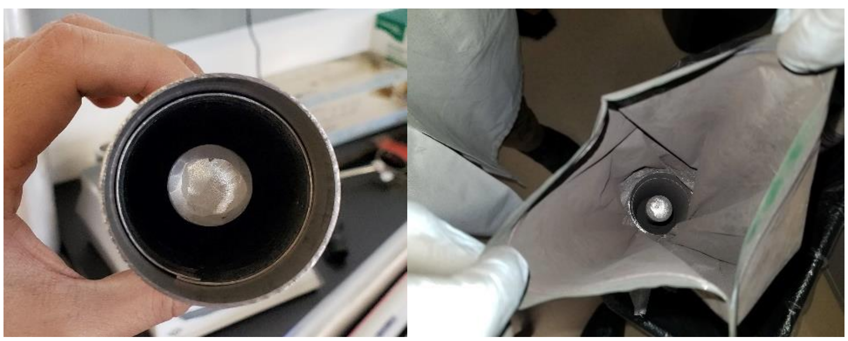

Figure 42: Interior of Al canister containing Cd sleeve and ^{10}B powder.

Because of that, the cadmium thickness was reduced by removing one 0.5 mm thick sleeve and the silver sleeve was completely excluded (as described previously in the MCNP final design section) to allow for as many ^{10}B atoms per unit thickness as possible. An MCNP model was ran to where the flux was first verified to be virtually unaffected before this design change was taken into consideration (see Figure 29). The setup of this design can be found in the schematic seen below. There was another variation that was made where natural boron carbide powder was substituted for natural boron powder. This substitution was done due to the lack of availability of natural boron powder. This alteration was then implemented after an MCNP model confirmed the sample flux remained unaffected as this component sits above the reactor and is thus outside of the bulk of the reactor flux. The exterior tubing of the 3-EL insert was also turned down (lower 30”) from 1.875” to 1.817” due to fitting issues with current 3-EL inserts. This was informed up by S.R.O. Larry Hall whom revealed that there are noticeable surface deposits that would accrue on the 3-EL after long periods inside the water of the reactor.

Two separate Al-canisters (annulus’) were created to hold the B_4C and ^{10}B powder. The latter annulus was done in the Engineering Teaching Center (ETC) machine shop by turning down a stock 1.68” x 1.75” x 25” tube to a reduced outer diameter of 1.73” so that it may fit inside the 3-EL tube. This was in response to the failure of initial plan that utilized two cadmium sleeves and one silver sleeve (when silver was still considered) to contain the packed boron powder along with a machined-out Al cap, plug and pneumatic sleeve.

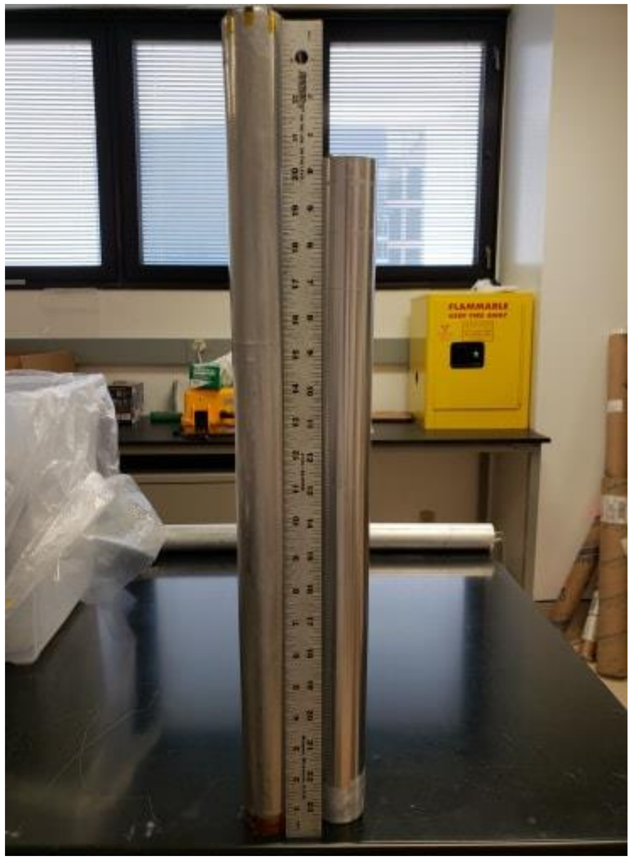

Figure 43: Packed components in the following order: Cd sleeves, Ag sleeve and ^{10}B powder all sealed in with fitted Al 6061-T6 lower cap, pneumatic sleeve (internal) and upper plug (LEFT, no longer in use); the other tube is the B_4C powder packed Al canister (RIGHT).

This design did achieve a successful packing and containment of boron powder but because it was composed of interlocking sleeves, it resulted in its expansion and thus increase in OD to be about 0.005" too big to fit. The interior of the 3-EL tube was also noted to be unusually "bumpy" which yielded uneven ID measurements throughout the length of the tube. This design did not fit in the instance that it would likely not be removable. It could have been forced all the way down the tube but was opted against such a design due to concerns of needing to disassemble the components.

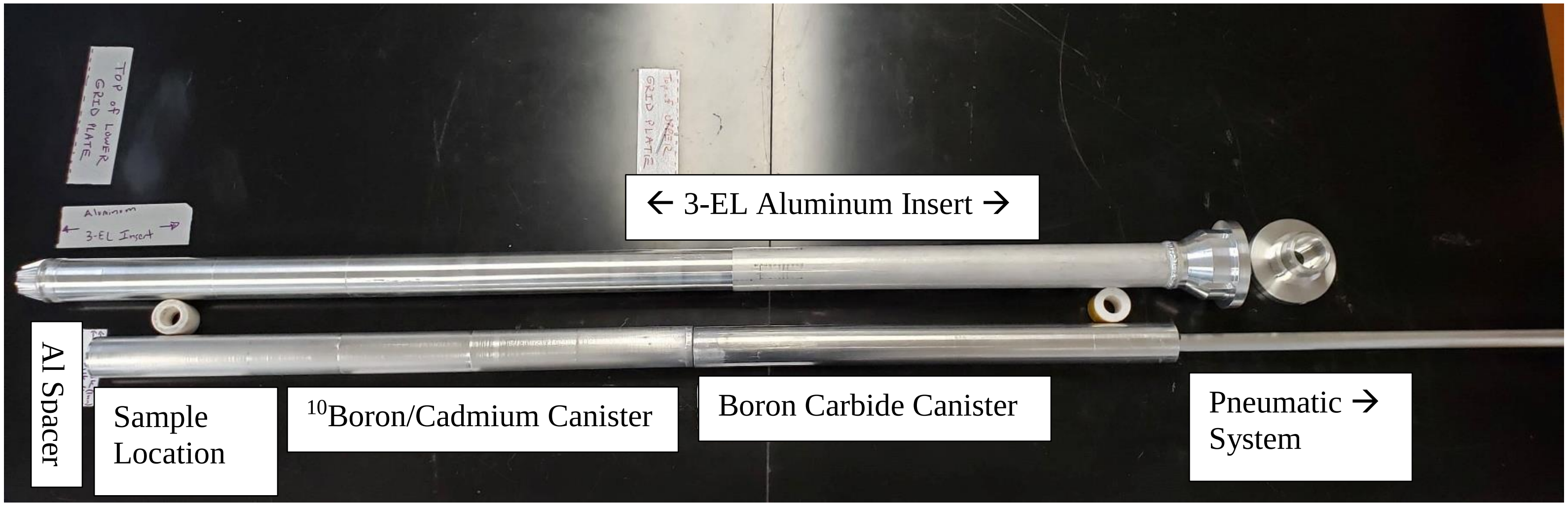

Figure 44: 3-EL insert with the fast neutron facility materials placed inside.

The annulus presented in Figure 42 was done via a job submission to the Center for Electromechanics at the University of Texas at Austin. The process of attaining a thin walled tube was not as simple as described above. This led to this result of numerous trial and errors in turning down other tube sizes to similar outer diameters such that it could fit inside the 3-EL tube and allow for a maximum capacity of boron powder thickness. This paved the way to the successful machining and welding of an Al canister with a wall thickness of about 0.020." It turned out to be too thin in wall thickness as it led to it collapsing on itself at a weld during packing (albeit aggressively) of the enriched powder. On the other hand, the Al annulus containing B_4C powder was easily packed because of its

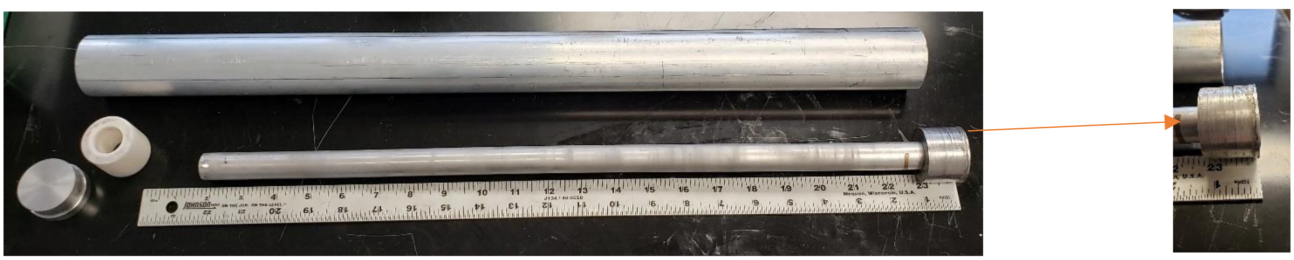

Figure 45: Location where the Al canister collapsed and subsequently broke from the weld.

0.1" wall thickness.

Thus, the canister shown below was made where the thickness came in at about 0.030" yielding an OD of 1.73" and an ID of 1.67." The pneumatic sleeve was remade as well and welded to a 0.25" inch pass through instead of the 1.5" pass through as it would lead to less likelihood of the sample encountering streaming thermal neutrons from the exposed section (area where no thermal/epithermal neutron attenuating material exists) during sample irradiation and transfer. The canister was also made to be approximately 1 inch longer reduce the possibility of streaming inside the 3-EL. The extra inch will extend to be approximately level with the upper grid plate, thus allowing for less neutrons to find the pneumatically transferred sample as it is being transported to and from the 3-EL insert.

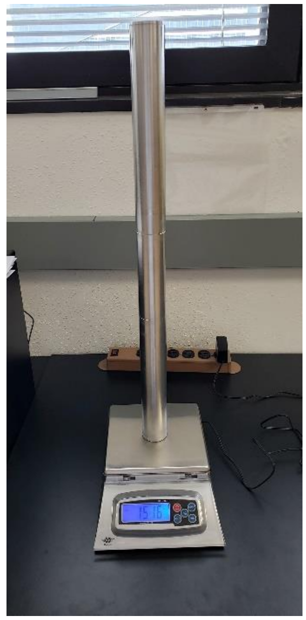

Figure 46: Fully packed, ^{10}B & Cd, Al canister.

Ultimately the assembled components should fit in the reactor core as shown in Figure 46:

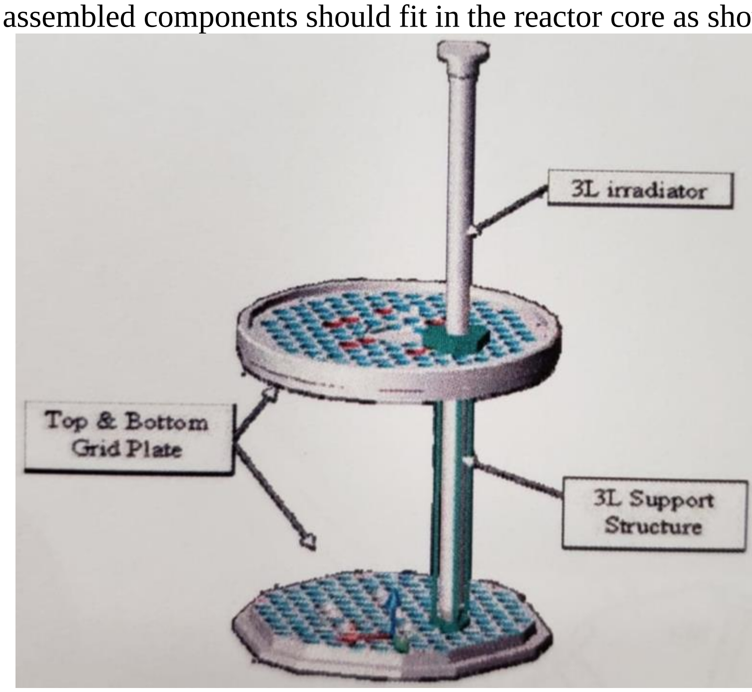

Figure 47: Depiction of how the 3-EL is to be inserted into the reactor core.

CHARACTERIZATION OF THE IN-CORE FACILITY

Al-Wire Irradiation to Determine Sample Location

The purpose of this experiment was to determine where in the z-axis, aka sample height, does the sample view the maximum flux in the reactor. This was conceived previously by former NETL director Steven Biegalski and performed by former NETL doctorate student, Matthew Paul. In the experiment performed by Matthew John Paul, an Al 4043 rod was placed inside a Pb-lined 3-EL. This rod was then cut into 1-inch increments where the $^{27}Al\ (n,\alpha)\ ^{24}Na$ reaction was counted via the ^{24}Na γ-rays.

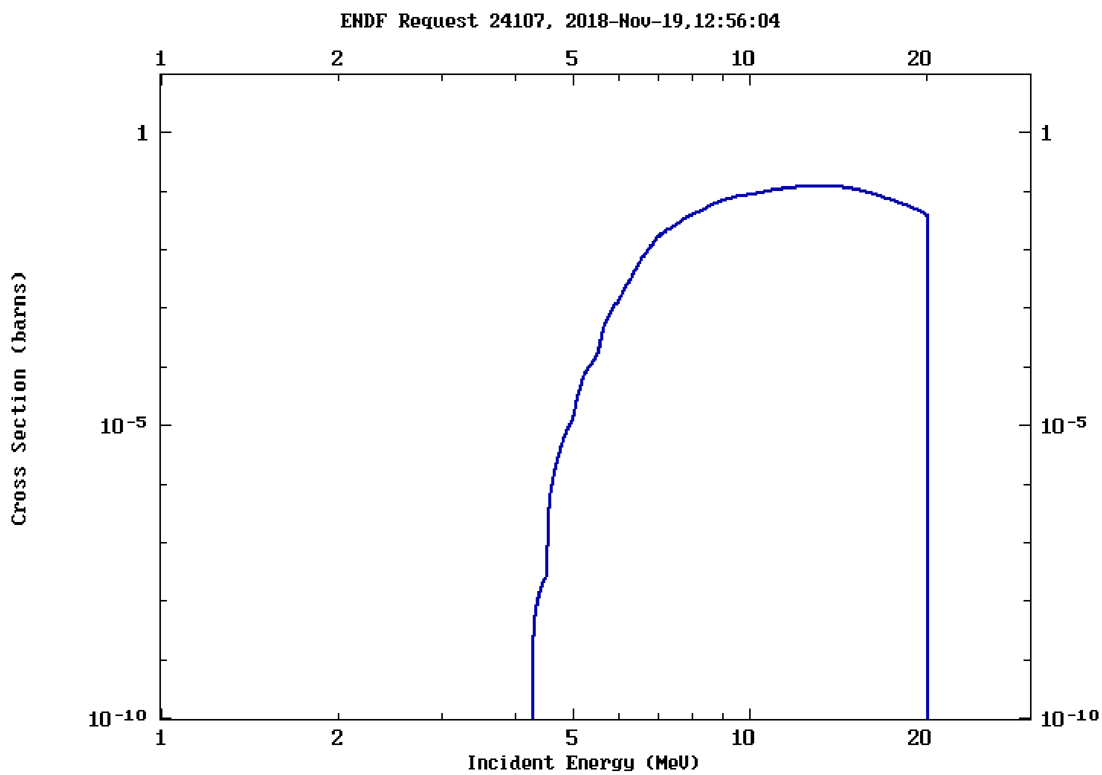

Figure 48: Nuclear cross-section of $^{27}Al\ (n,\alpha)\ ^{24}Na$.

The repeated experiment was done with a 99.9999% pure Al-wire fixed to a quartz tube that was then irradiated inside a Pb-lined 3-EL.

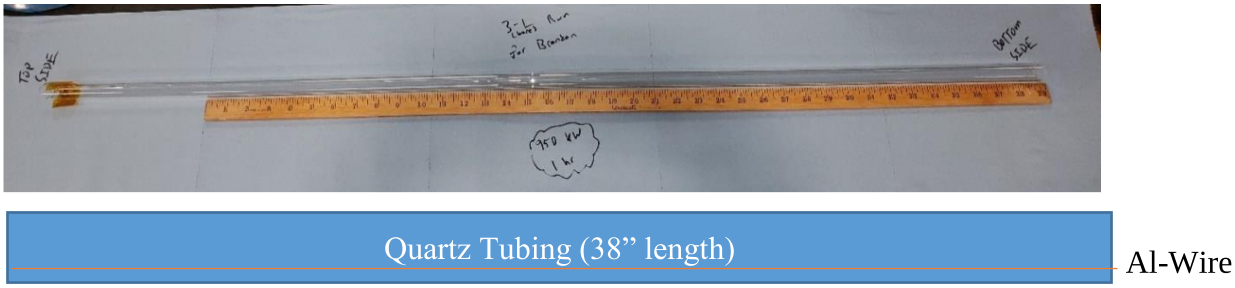

Figure 49: Nuclear cross-section of $^{27}Al\ (n,\alpha)\ ^{24}Na$.

This experiment confirmed the location found through Matt Paul’s trial and brought to light the difference between the two existing Pb-lined 3-EL’s where one contains a Pb sleeve and the other contains a Pb plug. The irradiation of the 99.9999% Al-wire took place in the Pb plugged facility while the Al 4043 rod took place in the other. The data for the Al-wire, which can be found in the following section of this thesis, yields an elevated maximal flux of approximately 5.5-6.0 inches when compared to the results yielded in the irradiation of the Al rod. It was noted that only 38 inches of quartz tubing were able to be fit inside the 3-EL whereas the data from Matt Paul’s experiment shows that he was able to fit 44 inches of Al 4043 rod.

Figure 50: Depth inside Pb-lined 3-EL used.

The image above shows that only about 41-42” length can fit inside the 3-EL. When referring to schematics it becomes clear that the pipe length of the 3-EL should be 48” in length leading to the idea that the “Pb-lined” 3-EL was really a Pb-plugged facility. This is believed to have led to the difference noted in the experimentally determined heights from the individual experiments. This discrepancy in maximum flux locations would serve to confirm three things: where the maximum flux is in the 3-EL (given the control rod heights used in each experiment are approximately the same), the height of the Pb plug and the consistency of the results of each data set.

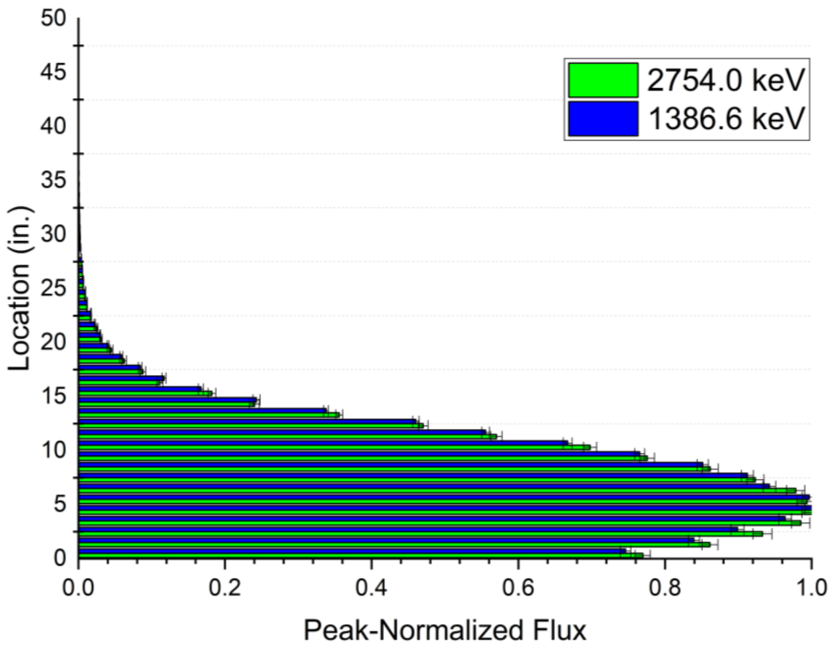

Figure 51: Al 4043 irradiation data following the reaction, $^{27}Al\ (n,\alpha)\ ^{24}Na$.

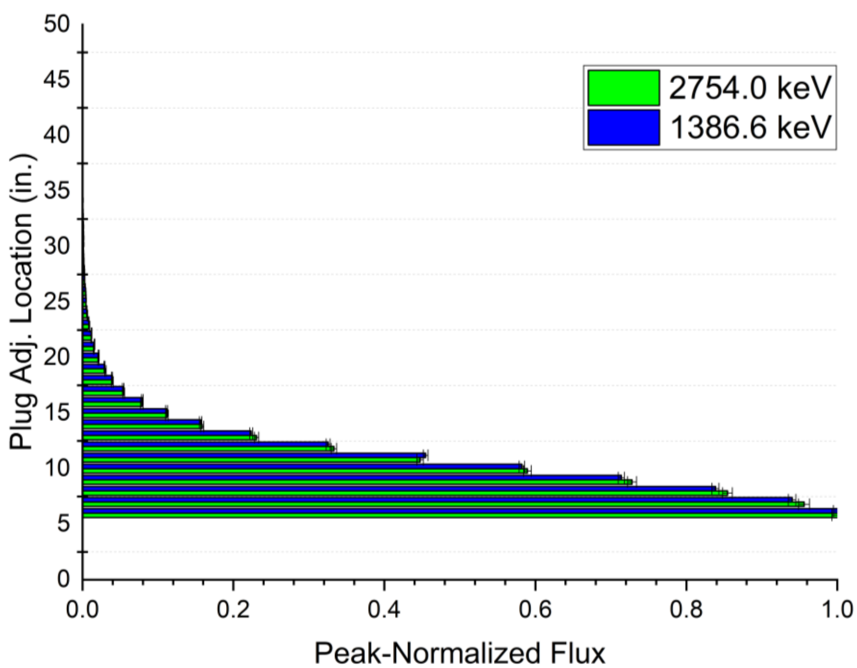

Figure 52: Al (99.9999%) wire irradiation data following the reaction, $^{27}Al\ (n,\alpha)\ ^{24}Na$.

The data shown above depicts the difference in experimentally acquired data as it relates to the height in the 3-EL insert used. The location of maximum flux was determined from this height adjustment that was necessary for both peak-normalized fluxes to match up. This shift was backed up by the experimental determination that the 3-EL's used were indeed different in how they use Pb in the facility.

Flux Wires for Fast Flux Calculations Using PNNL-STAYSL

In order to properly characterize the facility, flux wires will need to be inserted, irradiated and counted on an HPGe detector where the activation of said wires will be determined. The peaks taken from the gamma spectrum will be inserted into a software acquired from PNNL called, STAYSL. This software takes a predicted neutron flux spectrum, which will be supplied via the MCNP F4 tally output, and adjusts it depending on the activation of various nuclides in the flux wires. The flux wires will be chosen such that the desired activation of thermal, epithermal and fast reactions can all be analyzed. In the beam port 4 version of this facility, the selection of flux wires was important because of the lower flux and risk of not activating a nuclide enough to detect. Since this facility employs a total flux that is at least 10^6 orders of magnitude greater, the flux wire selection is not nearly as limited and can use a wider range to better adjust the spectrum.

Thermocouples for Temperature Profiling

The temperature of the facility has been of great interest in this thesis. Unlike the other fast neutron facility in beam port 4, whose flux is known to be at least 6 orders of magnitude lower, heating can be a very real issue. Therefore, due diligence is required to ensure the safety of the reactor and materials in the facility. That was the purpose of the previous section covering these heating calculations through three different forms. The facility will be probed through the insertion of a K-thermocouple into the pneumatic tubing down to irradiation position, once constructed. The temperature of the 3-EL facility will then be determined and plotted in a stepwise fashion of steady-state temperatures (K) vs. reactor power level (kW).

FINAL REMARKS

The 3-EL insert is expected to function as intended, allowing for the irradiation of samples under a predominantly fast neutron flux. This is backed up by a decent consistency in the modelling data using MCNP6 and SCALE 6.2.3. There should be no concern in the overheating of the facility due to the steps taken in producing a set of steady-state data. Once the pneumatic system comes online, it will allow for the automation of sample transfer and γγ spectroscopic analysis. From there, various radiochemical procedures will be implemented on Pu/U samples to determine the number of fissions occurring in the facility.

RECOMMENDATIONS FOR FUTURE WORK

The discovery of the reduced density of the boron powder was perhaps the only con of the facility as this material is what makes the flux approach the Watt fission spectrum. In the continuation of work in achieving a fast flux, boron powder will likely not be in consideration for use as the ^{10}B rich material. The only feasible approach using the powder in future instances would be to perform a thermohydraulic compression or sintering assisted compression of the powder into a “Green compact” (Al-Qureshi, Galiotto, & Klein, 2005; Corti, 1986; “Powder Metallurgy,” 2003; Sinka, 2007) in order to achieve a more comparable density to that of the boron carbide utilized by (Greenwood et al., 2014). The motivation of the use of the powder was the lack of structural stability that was needed as indicated in works utilizing boron carbide where cracks were very likely to form due to the daughter product buildup from the neutron absorption of ^{10}B (Chisela et al., 1986). If the scientific community were to desire a spectrum that were better representative of the Watt fission spectrum, a simple adjustment of this facility to the 7-EL irradiation zone could be made. This would require retrofitting the 3-EL with an annulus of enriched boron powder to further adjust the spectrum to the desired shape. To not require the building of a new pneumatic system, a new 7-EL spider grid attachment could be constructed to work in the pre-existing 3-EL location.

The experimental determination of heating in the facility is also recommended in the future once the pneumatic tubing is constructed and welded to the 3-EL insert. This should be done using K-thermocouples which would be fed down the pneumatic tubing to the irradiation position in the 3-EL where it will sit as the reactor is brought up in power, approaching 950 kW. This should then be compared against the computational predictions done on this Thesis and analyzed for comparability where any large differences should be dissected in detail. The flux of the facility should then be characterized using flux wires that contain threshold reactions that span across the neutron energy range 10^{-11} MeV to 20 MeV. The resulting decay radiation will be counted and input in PNNL-STAYSL (Greenwood & Johnson, 2016), a software that spectrally adjusts an input flux, ie F4 tally from MCNP, from threshold reactions acquired during experimental irradiations of flux wires.

APPENDIX

MCNP6 Input Deck

```
UT NETL TRIGA Mark II Nuclear Research Reactor MCNP Input Deck
c
c Created by: William H. Wilson
c Created on: 1 October 2014
c Last updated on: 8 January 2019
c Updated most recently by: Brandon A. De Luna
c ====================
c GENERAL INFORMATION:
c ====================
c
c Abut this MCNP input deck:
c =========================
c
c This MCNP input deck was created by William H. Wilson. It was created using
c MCNP version 6.1.1beta.
c
c This MCNP input deck was developed from an MCNP input deck that was created by
c Dr. Alexander G. Fay. William H. Wilson received the original input deck as
c an attachment to an email from Dr. Fay on 1 October 2014. For more information
c on the original input deck created by Dr. Fay, refer to Dr. Fay's doctoral
c dissertation, which is titled "Characterization of sources of radioargon in
c a research reactor."
c
c The geometry associated with the original MCNP input deck created by Dr. Fay
c has largely been retained in this input deck, but some geometry changes have
c been incorporated into this input deck. Additionally, several other aspects
c of the original input deck have been modified and some new features have
c been incorporated into this input deck.
c
c The University of Texas at Austin's TRIGA Mark II nuclear research reactor:
c ===========================================================================
c
c This MCNP input deck models the TRIGA Mark II nuclear research reactor housed
c at The University of Texas at Austin's (UT's) The Nuclear Engineering Teaching
c Laboratory (NETL). The NETL is situated in the north-eastern corner of UT's
c JJ Pickle Research Campus in Austin, Texas, USA. The reactor itself is a
c TRIGA Mark II nuclear research reactor with an effective full-power
c steady-state operating limit of about 1 MWt.
c
c The core associated with UT's TRIGA Mark II nuclear research reactor has a
c hexagonal structure with seven hexagonal "rings." The center "ring," consists
c of only one reactor core location designated A01. The second ring, the B ring,
c consists of six reactor core locations designated B01 through B06. The third
c ring, the C ring, consists of 12 reactor core locations designated C01 through
c C12. The fourth ring, the D ring, consists of 18 reactor core locations
c designated D01 through D18. The fifth ring, the E ring, consists of 24 reactor
c core locations designated E01 through E24. The sixth ring, the F ring,
c consists of 30 reactor core locations designated F01 through F30. And finally,
c the seventh ring, the G ring, also consists of 30 reactor core locations
c designated G02 through G06, G08 through G12, G14 through G18, G20 through G24,
c G26 through G30, and G32 through G36. Note that the corners of the G-ring
c hexagon are missing, and the designators that would have been associated with
c the missing core locations are skipped. In total there are 121 reactor core
c locations in UT's TRIGA Mark II nuclear research reactor. That said, only 111
c reactor core locations typically contain fuel elements; the other reactor core
c locations are either left empty (i.e. they are filled with water) or they
c contain irradiation facilities.
c
c UT's TRIGA Mark II nuclear research reactor contains a few different types of
```

c TRIGA fuel elements, but all of them have the same basic design. The fuel
c elements are cylindrical and have an outer diameter of about 3.73 cm and an
c overall length of about 72.06 cm. That said, the fueled region of the fuel
c elements is only about 38.10 cm long and consists of three UZrH fuel slugs
c stacked on top of each other. The UZrH is 8.5 % uranium, by weight, and the
c uranium is enriched to 19.7 % in U-235. Graphite slugs are situated at the
c top and bottom ends of the UZrH fuel slugs. The fuel elements are clad in
c stainless steel alloy 304. The top and bottom ends of the fuel elements have
c stainless steel alloy 304 fittings on them. For more information pertaining to
c the fuel elements, refer to section 4.4.5 of the Safety Analysis Report for
c The University of Texas at Austin's TRIGA Mark II nuclear research reactor
c (the version dated May 1991).
c
c The center reactor core location, reactor core location A01, typically
c contains the central thimble irradiation facility, which is basically a long
c aluminum tube that extends from about 19.0 cm below the bottom grid plate up
c to the reactor pool surface. The volume inside the central thimble irradiation
c facility is typically completely filled with water, but the upper portion of
c the central thimble irradiation facility may be blown dry so that a collimated
c beam of neutrons or gamma-rays can be made available to irradiate samples near
c the reactor pool surface.
c
c Reactor core location C01 contains the transient control rod, while reactor
c core locations C07, D06, and D14 contain the three fuel-followed control rods:
c the regulating rod and shim rods 1 and 2, respectively. The fuel-followed
c control rods are driven by stepping motors while the transient control rod,
c which is followed by an air-filled aluminum canister, is driven pneumatically.
c The neutron absorbing material in the control rods is boron carbide. For more
c information pertaining to the control rods, refer to section 4.4.8 of the
c Safety Analysis Report for The University of Texas at Austin's TRIGA Mark II
c nuclear research reactor (the version dated May 1991).
c
c Reactor core locations E11, F13, and F14 typically contain only a rack used to
c hold the 3-Element (3L) irradiation facility in position and are effectively
c filled with water, not the 3L irradiation facility or fuel elements. However,
c these reactor core locations may be occupied by either the 3L irradiation
c facility or three fuel elements depending on the configuration of the reactor
c core. Two different 3L irradiation facilities are available at UT's TRIGA
c Mark II nuclear research reactor: (1) the thermal 3L irradiation facility
c contains a lead sleeve and thus supports irradiating samples with both thermal
c and epithermal neutrons and (2) the epithermal 3L irradiation facility
c contains a cadmium sleeve and thus supports irradiating samples with
c only epithermal neutrons.
c
c Reactor core location G32 contains the AmBe startup source for a brief period
c each time the reactor startup procedure is performed, but the source is
c removed from the reactor core during reactor operations at power and reactor
c core location G32 is thus typically filled only with water.
c
c Reactor core location G34 is typically left empty (i.e. it is filled with
c water). However, it sometimes contains the pneumatic transfer system
c irradiation facility depending on the configuration of the reactor core.
c The pneumatic transfer system irradiation facility consists of a sender/
c receiver station, a blower, several meters of aluminum tubing, and an
c in-core terminus that allow for the rapid transfer of samples from the
c sender/receiver station to the in-core terminus and back again. The pneumatic
c transfer system irradiation facility is thus typically used to support
c irradiations producing radioisotopes with very short half-lives. For more
c information pertaining to the pneumatic transfer system irradiation facility,
c refer to section 8.1.3 of the Safety Analysis Report for The University of
c Texas at Austin's TRIGA Mark II nuclear research reactor (the version dated
c May 1991).
c
c A reactor reflector assembly surrounds the outer edges of the reactor core
c radially. The reactor reflector assembly is essentially a cylindrical graphite

```
c shell surrounded by an aluminum shroud. There are a number of penetrations and
c air volumes in the reactor reflector assembly that allow neutrons to stream
c from the reactor core out through the five beam ports. The beam ports are
c essentially aluminum and steel tubes that extend from the reactor reflector
c assembly out through the reactor pool water to the outer edges of the
c biological shield. For more information pertaining to the reactor reflector
c assembly, refer to section 4.4.2 of the Safety Analysis Report for The
c University of Texas at Austin's TRIGA Mark II nuclear research reactor
c (the version dated May 1991).
c
c A Rotary Specimen Rack (RSR) irradiation facility sits on top of the reactor
c reflector assembly. The RSR irradiation facility consists of 40 sample tubes
c in an aluminum housing. The sample tubes are about 3.18 cm in diameter  and
c about 27.4 cm deep. For more information pertaining to the RSR irradiation
c facility, refer to section 8.1.2 of the Safety Analysis Report for The
c University of Texas at Austin's TRIGA Mark II nuclear research reactor
c (the version dated May 1991).
c
c The reactor pool is an oblong cylinder that is filled with deionized water.
c The reactor core is positioned such that it is offset within the reactor pool
c and sits not in the center of the reactor pool, but off to the southern side
c of the reactor pool. A thin sheet of aluminum lines the inner surface of the
c biological shield and provides a barrier between the inner surface of the
c biological shield and the deionized reactor pool water.
c
c The biological shield itself has two levels that vary both geometrically and
c in composition. The cross-section associated with the lower level of the
c biological shield has a dodecagonal shape, while the cross-section associated
c with the upper level of the biological shield has an octagonal shape.
c The lower level of the biological shield consists of steel rebar reinforced
c high density concrete with a magnetite aggregate. The upper level of the
c biological shield on the other hand consists of a steel rebar reinforced
c standard density concrete, also with a magnetite aggregate. For more
c information pertaining to the biological shield, refer to section 7.2.1 of
c the Safety Analysis Report for The University of Texas at Austin's TRIGA
c Mark II nuclear research reactor (the version dated May 1991).
c
c The sections that follow provide additional information pertaining to the
c coordinate system employed in this MCNP input deck, and the way the fuel
c elements, the control rods, and the irradiation facilities available at
c The University of Texas at Austin's TRIGA Mark II nuclear research reactor
c are modeled in this input deck. Subsequent sections discuss features of UT's
c TRIGA Mark II nuclear research reactor that are not modeled in this input
c deck, variance reduction techniques employed in this input deck, and the
c warnings and comments generated during execution of this input deck.
c
c The coordinate system employed in this MCNP input deck:
c =======================================================
c
c The geometric origin of the rectangular coordinate system employed in this
c MCNP input deck (x0 = 0.0 cm, y0 = 0.0 cm, and z0 = 0.0 cm) is placed near the
c vertical center of the central axis of the reactor core. The positive-x axis
c of the coordinate system is defined such that it runs parallel to, and points
c in the opposite direction of, beam port 3. The positive-y axis of the
c coordinate system is defined such that it runs parallel to beam ports 1 and 5
c and points in the direction of beam port 1. The positive-z axis of the
c coordinate system is defined such that it points upward towards the surface
c of the reactor pool.
c
c Additional information pertaining to the modeling of the fuel elements:
c =======================================================================
c
c To model the fuel elements, an initial fuel element is first created as an
c MCNP universe (U=1) in reactor core location B01. This MCNP universe is
c composed of a fuel element surrounded by an infinite volume of water.
```

```
c MCNP surface coordinate transformations 0082 through 0198 are then used to
c define the displacements required to create additional fuel elements in
c other reactor core locations, where the required displacements are specified
c relative to the location of the fuel element in reactor core location B01.
c These MCNP surface coordinate transformations instruct MCNP to fill each of
c the fuel element cells (MCNP cells 0082 through 0198) with the portion of the
c fuel element universe (U=1) that actually contains the fuel element (as
c opposed to the infinite water volume). If we simply filled the fuel element
c cells with the fuel element universe and did not include the MCNP surface
c coordinate transformations MCNP would fill the fuel element cells with water.
c
c Additional information pertaining to the modeling of the
c fuel-followed control rods and the transient control rod:
c ==========================================================
c
c The fuel-followed control rods and the transient control rod are created
c as MCNP universes. The fuel-followed control rods are the regulating rod,
c shim rod 1, and shim rod 2. The transient rod is not a fuel-followed control
c rod; the transient rod is followed by an aluminum canister filled with air.
c The fuel-followed control rod universe (MCNP universe U=2) is created in the
c reactor core location occupied by the regulating rod (C07). The o1 and o2
c keywords associated MCNP surface coordinate transformation cards TR0104 and
c and TR0112 are used to displace MCNP universe U=2 and create shim rod 1 and
c shim rod 2 in reactor core locations D06 and D14, respectively. The transient
c rod universe (MCNP universe U=3) is created in the reactor core location
c occupied by the transient rod (C01).
c
c Using MCNP universes to create the fuel-followed and transient control rods
c makes it easy to adjust the vertical positions of the control rods. To adjust
c the vertical position of a given control rod the user needs only to modify the
c value assigned to the o3 keyword associated with the MCNP surface
c transformation card associated with the control rod of interest. The MCNP cell
c numbers and surface transformation numbers associated with each of the four
c control rods are summarized below along with the MCNP surface transformation
c card o3 keyword values corresponding to the full-in and full-out control
c rod positions:
c
c Control Rod   MCNP Cell #   MCNP Surf. Trans. #   Full-In o3   Full-Out o3
c -----------   -----------   -------------------   ----------   -----------
c Regulating       0093            0093              0.0 cm       38.1 cm
c   Shim 1         0104            0104              0.0 cm       38.1 cm
c   Shim 2         0112            0112              0.0 cm       38.1 cm
c Transient        0087            0087              0.0 cm       38.1 cm
c
c It should be noted that when the fuel-followed control rods are fully
c withdrawn from the reactor core their respective fuel-followers are vertically
c aligned with the fueled region of the reactor core. However, when the control
c rods are fully inserted their poison volumes do not vertically align with the
c fueled region of the reactor core - there is a slight offset. This aspect of
c this MCNP model is physically realistic and consistent with the positioning of
c the control rods in UT's TRIGA MARK II nuclear research reactor.
c
c Additional information pertaining to the modeling
c of the central thimble irradiation facility:
c ==================================================
c
c Reactor core location A01 typically contains the central thimble irradiation
c facility, and the volume inside the central thimble irradiation facility is
c typically completely filled with water. However, when the central thimble
c irradiation facility is in use, the volume inside the portion of the central
c thimble irradiation facility above the top of the top grid plate may be filled
c with air, allowing a highly collimated beam of radiation to stream upward from
c the reactor core to a sample placed at the upper end of the central thimble
c irradiation facility, somewhere just above the reactor pool surface. The
c central thimble irradiation facility may also be removed from the reactor core
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c entirely. The instructions that follow provide some basic guidance that may be
c used to fill reactor core location A01 with the central thimble irradiation
c facility or water. It should be noted that thought should be given to
c additional modifications beyond those listed below that may be required to
c support more specialized changes in the reactor core configuration.
c
c How to fill reactor core location A01 with
c the central thimble irradiation facility:
c ----------------------------------------
c
c Note that additional instructions specific to filling the volume inside
c the central thimble irradiation facility with either water or air are
c provided with the central thimble irradiation facility cell cards.
c
c (1) Verify that MCNP cells 0221, 0222, 0223, 0224, and 0225 are active.
c (2) Verify that MCNP surfaces 0071 through 0078 are active.
c (3) Verify that MCNP compliments 0221, 0222, 0223, 0224, and 0225 (#0221,
c     #0222, #0223, #0224, and #0225, respectively) are included in the list
c     of compliments associated with MCNP cell 0411.
c (4) Verify that any MCNP cells used to model samples inside the air/water-
c     filled volume inside the central thimble irradiation facility (MCNP cells
c     0223 and/or 0224) are active. Also verify that any MCNP surfaces used
c     exclusively to define these MCNP cells are active. Additionally, verify
c     that any MCNP compliments associated with MCNP cells used to model
c     samples inside the air/water-filled volume inside the central thimble
c     irradiation facility are included in the list of compliments associated
c     with MCNP cells 0223 and/or 0224.
c (5) Verify that any tallies evaluated in MCNP cells used to model samples
c     inside the air/water-filled volume inside the central thimble irradiation
c     facility are active.
c (6) Verify that the WWINP file called at the execution line includes an
c     appropriate number of lower weight-window bounds. This verification is
c     especially important if the central thimble irradiation facility
c     is just being introduced to the reactor core.
c
c How to fill reactor core location A01 with water:
c ------------------------------------------------
c
c (1) Verify that MCNP cells 0221, 0222, 0223, 0224, and 0225 are commented out.
c (2) Verify that MCNP surfaces 0071 through 0078 are commented out.
c (3) Verify that MCNP compliments 0221, 0222, 0223, 0224, and 0225 (#0221,
c     #0222, #0223, #0224, and #0225, respectively) are not included in the
c     list of compliments associated with MCNP cell 0411.
c (4) Verify that any MCNP cells that may have been used to model samples
c     inside the air/water-filled volume inside the central thimble irradiation
c     facility (MCNP cells 0223 and/or 0224) are commented out. Also verify that
c     any MCNP surfaces used exclusively to define these MCNP cells are
c     commented out. Additionally, verify that any MCNP compliments associated
c     with MCNP cells that may have been used to model samples inside the air/
c     water-filled volume inside the central thimble irradiation facility are
c     not included in the list of compliments associated with MCNP cells 0223
c     and/or 0224.
c (5) Verify that any tallies that may have been evaluated in MCNP cells
c     used to model samples inside the air/water-filled volume inside the
c     central thimble irradiation facility are commented out.
c (6) Verify that the WWINP file called at the execution line includes an
c     appropriate number of lower weight-window bounds. This verification is
c     especially important if the central thimble irradiation facility
c     is just being removed from the reactor core.
c
c Additional information pertaining to the modeling
c of the 3-Element (3L) irradiation facility:
c =================================================
c
c The reactor core locations E11, F13, and F14 typically contain only a rack
```

```
c used to hold the 3L irradiation facility in position and are effectively
c filled with water, not the 3L irradiation facility or fuel elements. However,
c these reactor core locations may be occupied by either the 3L irradiation
c facility or three fuel elements depending on the configuration of the
c reactor core. The instructions that follow provide some basic guidance that
c may be used to fill the 3L irradiation facility reactor core locations with
c water, the 3L irradiation facility, or three fuel elements. It should be
c noted that thought should be given to additional modifications beyond those
c listed below that may be required to support more specialized changes in
c the reactor core configuration.
c
c How to fill reactor core locations E11, F13, and F14 with water:
c ----------------------------------------------------------------
c
c  (1) Verify that MCNP cells 0127, 0153, and 0154 are commented out.
c  (2) Verify that MCNP surface coordinate transformation cards 0127,
c      0153, and 0154 (TR0127, TR30153, and TR0154, respectively) are
c      commented out.
c  (3) Verify that MCNP compliments 0127, 0153, and 0154 (#0127, #0153,
c      and #0154, respectively) are not included in the list of
c      compliments associated with MCNP cell 0411.
c  (4) Verify that MCNP cells 0231 through 0237 are commented out.
c  (5) Verify that MCNP compliment 0237 (#0237) is not included in the
c      list of compliments associated with MCNP cell 0411.
c  (6) Verify that MCNP surfaces 0081 through 0094 are commented out.
c  (7) Verify that MCNP surfaces 0086, 0258, 0284, and 0285 are not
c      included in the list of surfaces used to define MCNP cell 0371.
c  (8) Verify that any MCNP cells that may have been used to model samples
c      inside the inner CO2-purged volume of the 3L irradiation facility
c      (MCNP cell 0235) are commented out. Also verify that any MCNP surfaces
c      used exclusively to define these MCNP cells are commented out.
c      Additionally, verify that any MCNP compliments associated with MCNP
c      cells that may have been used to model samples inside the inner
c      CO2-purged volume of the 3L irradiation facility are not included
c      in the list of compliments associated with MCNP cell 0235.
c  (9) Verify that the initial source point locations specified on the KSRC
c      card for reactor core locations E11, F13, and F14 are commented out.
c (10) Verify that any tallies that may have been evaluated in MCNP cells
c      used to model samples inside the inner CO2-purged volume of the
c      3L irradiation facility are commented out.
c (11) Verify that the WWINP file called at the execution line includes an
c      appropriate number of lower weight-window bounds. This verification is
c      especially important if either the three fuel elements or the
c      3L irradiation facility are just being removed from the reactor
c      core locations associated with the 3L irradiation facility.
c
c How to fill reactor core locations E11, F13,
c and F14 with the 3L irradiation facility:
c --------------------------------------------
c
c Note that additional instructions specific to selecting either the
c cadmium (epithermal) 3L irradiation facility sleeve or the lead
c (thermal) 3L irradiation facility sleeve are provided with the
c 3L irradiation facility cell cards.
c
c  (1) Verify that MCNP cells 0127, 0153, and 0154 are commented out.
c  (2) Verify that MCNP surface coordinate transformation cards 0127,
c      0153, and 0154 (TR0127, TR30153, and TR0154, respectively) are
c      commented out.
c  (3) Verify that MCNP compliments 0127, 0153, and 0154 (#0127, #0153,
c      and #0154, respectively) are not included in the list of
c      compliments associated with MCNP cell 0411.
c  (4) Verify that MCNP cells 0231 through 0237 are active.
c  (5) Verify that MCNP compliment 0237 (#0237) is included in the
c      list of compliments associated with MCNP cell 0411.
```

```
c  (6) Verify that MCNP surfaces 0081 through 0094 are active.
c  (7) Verify that MCNP surface 0086 is included in the list of surfaces used
c      to define MCNP cell 0371. Verify that MCNP surfaces 0258, 0284, and 0285
c      are not included in the list of surfaces used to define MCNP cell 0371.
c  (8) Verify that any MCNP cells used to model samples inside the inner
c      CO2-purged volume of the 3L irradiation facility (MCNP cell 0235)
c      are active. Also verify that any MCNP surfaces used exclusively to
c      define these MCNP cells are active. Additionally, verify that the MCNP
c      compliments associated with MCNP cells used to model samples inside the
c      inner CO2-purged volume of the 3L irradiation facility are included in
c      the list of compliments associated with MCNP cell 0235.
c  (9) Verify that the initial source point locations specified on the KSRC
c      card for reactor core locations E11, F13, and F14 are commented out.
c (10) Verify that any tallies evaluated in MCNP cells used to model samples
c      inside the inner CO2-purged volume of the 3L irradiation facility
c      are active.
c (11) Verify that the WWINP file called at the execution line includes an
c      appropriate number of lower weight-window bounds. This verification is
c      especially important if the 3L irradiation facility is just being
c      introduced to the reactor core locations associated with the
c      3L irradiation facility.
c
c How to fill reactor core locations E11, F13, and F14 with three fuel elements:
c -----------------------------------------------------------------------------
c
c  (1) Verify that MCNP cells 0127, 0153, and 0154 are active.
c  (2) Verify that MCNP surface coordinate transformation cards 0127,
c      0153, and 0154 (TR0127, TR30153, and TR0154, respectively) are active.
c  (3) Verify that MCNP compliments 0127, 0153, and 0154 (#0127, #0153,
c      and #0154, respectively) are included in the list of compliments
c      associated with MCNP cell 0411.
c  (4) Verify that MCNP cells 0231 through 0237 are commented out.
c  (5) Verify that MCNP compliment 0237 (#0237) is not included in the
c      list of compliments associated with MCNP cell 0411.
c  (6) Verify that MCNP surfaces 0081 through 0094 are commented out.
c  (7) Verify that MCNP surface 0086 is not included in the list of
c      surfaces used to define MCNP cell 0371. Verify that MCNP surfaces
c      0258, 0284, and 0285 are included in the list of surfaces used
c      to define MCNP cell 0371.
c  (8) Verify that any MCNP cells that may have been used to model samples
c      inside the inner CO2-purged volume of the 3L irradiation facility
c      (MCNP cell 0235) are commented out. Also verify that any MCNP surfaces
c      used exclusively to define these MCNP cells are commented out.
c      Additionally, verify that any MCNP compliments associated with MCNP
c      cells that may have been used to model samples inside the inner
c      CO2-purged volume of the 3L irradiation facility are not
c      included in the list of compliments associated with MCNP cell 0235.
c  (9) Verify that the initial source point locations specified on
c      the KSRC card for reactor core locations E11, F13, and active.
c (10) Verify that any tallies that may have been evaluated in MCNP cells
c      used to model samples inside the inner CO2-purged volume of
c      the 3L irradiation facility are commented out.
c (11) Verify that the WWINP file called at the execution line includes an
c      appropriate number of lower weight-window bounds. This verification is
c      especially important if the three fuel elements are just being
c      introduced into the reactor core locations associated with
c      the 3L irradiation facility.
c
c Additional information pertaining to the modeling
c of the pneumatic transfer system irradiation facility:
c =======================================================
c
c Reactor core location G34 is typically left empty (i.e. it is filled
c with water). However, it sometimes contains the pneumatic transfer system
c irradiation facility, depending on the configuration of the reactor core.
```

```
c The instructions that follow provide some basic guidance that may be used to
c fill reactor core location G34 with water or the pneumatic transfer system
c irradiation facility irradiation facility. It should be noted that thought
c should be given to additional modifications beyond those listed below that
c may be required to support more specialized changes in the reactor
c core configuration.
c
c How to fill reactor core location G34 with water:
c -------------------------------------------------
c
c (1) Verify that MCNP cells 0271, 0272, 0273, 0274, and 0275 are commented out.
c (2) Verify that MCNP surfaces 0121 through 0131 are commented out.
c (3) Verify that MCNP compliments 0271, 0272, 0273, 0274, and 0275 (#0271,
c     #0272, #0273, #0274, and #0275, respectively) are not included in
c     the list of compliments associated with MCNP cell 0411.
c (4) Verify that any MCNP cells used to model samples inside the air-filled
c     inner volume of the pneumatic transfer system irradiation facility
c     (MCNP cell 0271) are commented out. Also verify that any MCNP surfaces
c     used exclusively to define these MCNP cells are commented out.
c     Additionally, verify that any MCNP compliments associated with MCNP
c     cells used to model samples inside the air-filled inner volume of
c     the pneumatic transfer system irradiation facility are not included
c     in the list of compliments associated with MCNP cell 0271.
c (5) Verify that any tallies evaluated in MCNP cells used to model samples
c     inside the inner air-filled volume of the pneumatic transfer system
c     irradiation facility are commented out.
c (6) Verify that the WWINP file called at the execution line includes an
c     appropriate number of lower weight-window bounds. This verification is
c     especially important if the pneumatic transfer system irradiation
c     facility is just being removed from the reactor core.
c
c How to fill reactor core location G34 with the
c pneumatic transfer system irradiation facility:
c -----------------------------------------------
c
c Note that additional instructions specific to selecting either the cadmium
c (epithermal) pneumatic transfer system irradiation facility sleeve or the
c lead (thermal) pneumatic transfer system irradiation facility sleeve are
c provided with the pneumatic transfer system irradiation facility cell cards.
c
c (1) Verify that MCNP cells 0271, 0272, 0273, 0274, and 0275 are active.
c (2) Verify that MCNP surfaces 0121 through 0131 are active.
c (3) Verify that MCNP compliments 0271, 0272, 0273, 0274, and 0275 (#0271,
c     #0272, #0273, #0274, and #0275, respectively) are included in the list
c     of compliments associated with MCNP cell 0411.
c (4) Verify that any MCNP cells used to model samples inside the air-filled
c     inner volume of the pneumatic transfer system irradiation facility
c     (MCNP cell 0271) are active. Also verify that any MCNP surfaces used
c     exclusively to define these MCNP cells are active. Additionally, verify
c     that any MCNP compliments associated with MCNP cells used to model
c     samples inside the air-filled inner volume of the pneumatic transfer
c     system irradiation facility are included in the list of compliments
c     associated with MCNP cell 0271.
c (5) Verify that any tallies evaluated in MCNP cells used to model samples
c     inside the inner air-filled volume of the pneumatic transfer system
c     irradiation facility are active.
c (6) Verify that the WWINP file called at the execution line includes an
c     appropriate number of lower weight-window bounds. This verification is
c     especially important if the pneumatic transfer system irradiation
c     facility is just being introduced to the reactor core.
c
c Features of the UT TRIGA Mark II nuclear research
c reactor that are not modeled in this MCNP input deck:
c =====================================================
c
```

```
c While a considerable amount of effort has been expended to incorporate the
c majority of the major features of the UT TRIGA Mark II nuclear research
c reactor into this MCNP input deck, there are several features of the UT TRIGA
c Mark II nuclear research reactor that are not included in this MCNP input
c deck. Some of the more notable features that are not modeled in this MCNP
c input deck include the following:
c
c (1) The fuel element composition assumed in this MCNP input deck is the fuel
c     element composition representative of a clean reactor core. That is to say
c     that the composition of each modeled fuel element is assumed to be that of
c     a brand new, never burned fuel element. Additionally, the fuel element
c     composition is assumed to be uniform throughout the volume of a given
c     fuel element, and all of the fuel elements are assumed to have the same
c     composition regardless of their location within the reactor core.
c     In reality the UT TRIGA Mark II nuclear research reactor has been
c     operational since 1992, and a large portion of the fuel elements were also
c     burned in UT's original research reactor which operated from August 1963
c     until the TRIGA Mark II nuclear research reactor went into operation in
c     1992, so the fuel elements contain less uranium than brand new, never
c     burned fuel elements. They also contain various neutron fission products
c     that would not be present in brand new, never burned fuel elements.
c     Assuming a fuel element composition representative of a clean reactor core
c     as opposed to the fuel element composition specific to a given time in
c     core life introduces some error into the output generated by this MCNP
c     model. That said, the magnitude of the error is difficult to estimate.
c
c (2) The temperature profile across the geometry of the UT TRIGA Mark II
c     nuclear research reactor is essentially assumed to be uniform at
c     T = 293.6 K. One notable exception is the temperature of the uranium
c     zirconium hydride material in each of the fuel elements, which is assumed
c     to be uniform at T = 600 K. Assuming a uniform temperature profile across
c     the geometry of the UT TRIGA Mark II nuclear research reactor introduces
c     some error into the output generated by this MCNP model. That said, the
c     magnitude of the error is difficult to estimate.
c
c (3) With the exception of the air cavity common to stage 1 of beam ports 1
c     and 5, the beam ports are modeled simply as air-filled tubes. Some notable
c     features of the UT TRIGA Mark II nuclear research reactor beam ports that
c     are not modeled in this MCNP input deck include the shield plugs that are
c     typically installed in beam ports 1 and 4 and the neutron wave guide that
c     is typically installed in beam port 3.
c
c (4) This MCNP input deck models the portion of the UT TRIGA Mark II nuclear
c     research reactor that extends from the bottom of the reactor pool up
c     through an elevation of 95 cm above the vertical center of the reactor
c     core. Horizontally the model extends out to the outer edges of the lower
c     level of the biological shield. It is thus important to note that this
c     MCNP input deck does not model the entire vertical extent of the UT TRIGA
c     Mark II nuclear research reactor, nor does it model any of the
c     experimental facilities outside of the biological shield.
c
c
c Information pertaining to the variance reduction
c techniques employed in this MCNP input deck:
c ================================================
c
c The principal variance reduction technique employed in this MCNP input deck is
c the weight-window population control technique. An initial set of cell-based
c lower weight-window bounds must be provided by the user in a separate WWINP
c file. The name of the WWINP file containing the cell-based lower weight-window
c bounds must be communicated to MCNP at the execution line using the WWINP
c keyword. The MCNP weight-window generator then generates a new, improved set
c of cell-based lower weight-window bounds that may be utilized by a subsequent
c continue run. The process of executing an MCNP run, generating a new, improved
c set of lower weight window bounds and then utilizing the new, improved set of
```

```
c lower weight window bounds in a continue run may be repeated a number of times
c to ensure that an optimal set of lower weight-window bounds has been
c generated. Then, once an optimal set of lower weight-window bounds has been
c generated, a final continue run requesting that a relatively large number of
c particle histories be run may be executed to minimize the variances associated
c with the tallies requested in a manner that is as efficient as possible. This
c variance reduction technique is particularly powerful when tallies are
c requested in MCNP cells that have volumes that are very small relative to the
c volume associated with the overall problem geometry.
c
c The WWINP file that supports this MCNP input deck must contain a lower
c weight-window bound for each of the cells associated with the problem
c geometry. The lower weight-window bound associated with the particle graveyard
c should be set equal to zero so that particles entering the particle graveyard
c will be killed. It is difficult to estimate what the lower weight-window
c bounds associated with the other cells associated with the problem geometry
c should be (this is, after all, why we are using the weight window generator
c to establish the lower weight-window bounds for us). Experience has shown that
c setting the lower weight-window bounds associated with the other cells
c associated with the problem geometry to 0.5 (one half of the weight that
c source particles are born with by default) allows MCNP to run the particle
c histories requested herein relatively quickly and efficiently without
c introducing any spatial bias to the output generated by this MCNP input deck.
c
c Additional weight-window generator options may be set using the WWP and
c cards. See the comments associated with the WWP and WWG cards for more
c information pertaining to these options.
c
c For more information pertaining to the weight-window population control
c variance reduction technique and the MCNP weight window generator refer to
c section 3.3.6 of the MCNP6 User's Manual (LA-CP-14-00745, Rev. 0) and
c volume I, chapter 2, section VII.B.5 of "MCNP — A General Monte Carlo
c N-Particle Transport Code, Version 5" (LA-UR-03-1987). Additionally, the
c "MCNP Reference Collection," which is available at https://laws.lanl.gov/...
c vhosts/mcnp.lanl.gov/references.shtml also includes several references on the
c weight-window population control technique and the MCNP weight window
c generator.
c
c Warnings and comments generated during execution of this MCNP input deck:
c ===========================================================================
c
c Warnings generated during the execution of this MCNP input deck:
c ----------------------------------------------------------------
c
c Three warnings are generated during the execution of this MCNP input deck.
c A summary of the warnings generated and their respective meanings follows.
c None of the warnings are cause for concern.
c
c (1) Warning: Physics models disabled.
c
c    Warning resolution: The MODE card in this MCNP input deck includes only
c    an "N" designator to specify that MCNP should transport only neutrons.
c    All MODE N, P, and E problems run with model physics turned off by
c    default. See section 3.3.3.7 of the MCNP6 User's Manual (LA-CP-14-00745,
c    Rev. 0) for more information. This warning may be disregarded.
c
c (2) Warning: Energy of the top neutron weight-window bound set to emax.
c
c    Warning resolution: This MCNP input deck does not employ a WWE card, so
c    a single weight-window energy interval is established with lower and
c    upper energy bounds equal to the energy limits of the problem. See
c    section 3.3.6.3 of the MCNP6 User's Manual (LA-CP-14-00745, Rev. 0)
c    for more information. This warning may be disregarded.
c
c (3) Warning: 001001.80c and 001001.81c are both called for.
```

```
c
c    Warning resolution: ZAID 001001.80c specifies that continuous energy
c    neutron data for H-1 in several materials, including the reactor pool
c    water and the high density concrete associated with the biological
c    shield, should be extracted from data library 80. H-1 data library 80
c    provides H-1 data for H-1 at T = 293.6 K. ZAID 001001.81c specifies that
c    continuous energy neutron data for H-1 in the UZrH fuel elements should
c    be extracted from data library 81. H-1 data library 81 provides H-1 data
c    for H-1 at T = 600 K. 001001.80c and 001001.81c are both called for
c    intentionally because H-1 data is needed for both of the aforementioned
c    temperatures. This warning may be disregarded.
c
c Comments generated during the execution of this MCNP input deck:
c ----------------------------------------------------------------
c
c Six comments are generated during the execution of this MCNP input deck.
c A summary of the comments generated and their respective meanings follows.
c None of the comments are cause for concern.
c
c (1) Comment: Total fission nubar data are being used.
c
c    Comment resolution: This KCODE card in this MCNP input deck specifies the
c    MCNP criticality source that is used for determining k-effective. The
c    criticality source uses total fission nubar data unless a TOTNU card is
c    used to specify that only prompt nubar data should be used. This MCNP
c    input deck does not employ a TOTNU card. See section 3.3.2.6 of the MCNP6
c    User's Manual (LA-CP-14-00745, Rev. 0) for more information. This comment
c    may be disregarded.
c
c (2) Comment: 117 surfaces were deleted for being the same as others.
c
c    Comment resolution: To create the 40 RSR sample tubes, a single RSR
c    sample tube, RSR sample tube 01, is first modeled using cell card form 1.
c    The remaining 39 RSR sample tubes are then modeled using cell card form 2
c    with cell coordinate transformations applied. This essentially creates
c    39 copies of RSR sample tube 01 transformed to the appropriate positions
c    within the RSR. Each time a copy of sample tube 01 is created and then
c    transformed, the three horizontal MCNP surfaces used to define the
c    boundaries of RSR sample tube 01 are copied and transformed to the
c    appropriate positions within the RSR. Because the z-component associated
c    with each of the transformations is zero, the copied and transformed
c    horizontal MCNP surfaces end up being the same as the original horizontal
c    MCNP surfaces used to define the boundaries of RSR sample tube 01.
c    MCNP recognizes that the surfaces are the same, deletes the duplicates,
c    and generates a comment to notify the user that the duplicate surfaces
c    were deleted. This comment may be disregarded.
c
c (3) Comment: Using random number generator 1, initial seed = 219008682294439.
c
c    Comment resolution: The "GEN" keyword on the RAND card is set equal to 1
c    to specify that random number generator 1, the MCNP Lehmer 48-bit
c    congruential pseudorandom number generator, should be used (this is the
c    default pseudorandom number generator in MCNP 6.1.1b). Also, the "SEED"
c    keyword on the RAND card is set equal to 219,008,682,294,439 to set the
c    pseudorandom number generator seed equal to 219,008,682,294,439. The
c    reason for setting the pseudorandom number generator seed equal to
c    219,008,682,294,439 is discussed in the comments near the RAND card;
c    refer to the discussion there for more information. Additional information
c    may also be found in section 3.3.7.3.1 of the MCNP6 User's Manual
c   (LA-CP-14-00745, Rev. 0). This comment may be disregarded.
c
c (4) Comment: Nine cross-sections modified by free-gas thermal treatment.
c
c    Comment resolution: This MCNP input deck employs four thermal neutron
c    scattering cards, or MT cards. These four MT cards override the free-gas
```

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c    treatment associated with nine cross-sections at low energies where
c    thermal neutron scattering data is available: (1) MT card MT03 provides
c    thermal neutron scattering data for natural carbon in graphite at
c    T = 293.6 K; (2) MT card MT05 provides thermal neutron scattering data
c    for H-1, Zr-90, Zr-91, Zr-92, Zr-94, and Zr-96 in zirconium hydride at
c    T = 600 K; (3) MT card MT07 provides thermal neutron scattering data
c    for H-1 in water at T = 293.6 K; and (4) MT card MT09 provides thermal
c    neutron scattering data for Al-27 at T = 293.6 K. In order to properly
c    model the scattering of thermal neutrons, it is essential that the
c    free-gas treatment be overridden at low energies where thermal neutron
c    scattering data is available. See section 3.3.2.2 of the MCNP6 User's
c    Manual (LA-CP-14-00745, Rev. 0) for more information. This comment may
c    be disregarded.
c
c (5) Comment: Setting up hash-based fast table search for xsec tables.
c
c    Comment resolution: MCNP6.1.1 beta employs a new hash-based cross-section
c    lookup algorithm. The new hash-based cross-section lookup algorithm is
c    15-20 faster than the conventional algorithm employed by older versions
c    of MCNP. For more information see the presentation by Dr. Forrest Brown
c    (Senior Research Scientist, Los Alamos National Laboratory) titled
c    "New Hash-based Energy Lookup Algorithm for Monte Carlo Codes"
c    (LA-UR-14-27037). This comment may be disregarded.
c
c (6) Comment: Entropy of the fission source distribution will be computed.
c
c    Comment resolution: MCNP computes a quantity called the Shannon entropy
c    of the fission source distribution to assist in assessing the convergence
c    of the fission source distribution. To compute the Shannon entropy of the
c    fission source distribution a three-dimensional grid encompassing all of
c    the fissionable regions is superimposed on the problem geometry and then
c    the number of fission sites that fall into each of the grid boxes is
c    tallied. The user may use the HSRC card to request that a particular grid
c    be used to evaluate the Shannon entropy. This MCNP input deck does not
c    employ an HSRC card, so MCNP automatically determines a grid that encloses
c    all of the fission sites. The grid is expanded as necessary if fission
c    source sites for a given KCODE cycle fall outside of the grid. See
c    section 3.3.4.12 of the MCNP6 User's Manual (LA-CP-14-00745, Rev. 0)
c    for more information. This comment may be disregarded.
c
c ================
c MCNP CELL CARDS:
c ================
c
c Cell cards modeling the particle graveyard:
c ===========================================
c
c A single cell card, cell card 0001, is used to model the particle graveyard.
c
c    m                  geom
c    --  -------------------------------------------------------
0001  00  -0547 :  0541 :  0544 : -0550 :  0552 :  0551 :  0542 :
          0543 :  0548 :  0549 :  0546 :  0545 :  0519 : -0518
c
c Cell cards modeling the fuel element universe:
c ==============================================
c
c Ten cell cards are used to model the fuel element universe:
c  (1) Cell 0011 represents the stainless steel tri-flute at the upper
c      end of the fuel element.
c  (2) Cell 0012 represents the stainless steel cladding that covers the
c      outer cylindrical surfaces of the fuel element.
c  (3) Cell 0013 represents the air gap above the graphite slug at the
c      upper end of the fuel element.
c  (4) Cell 0014 represents the graphite slug at the upper end of
```

```
c      the fuel element.
c  (5) Cell 0015 represents the zirconium rod that runs the length of
c      the fueled region of the fuel element.
c  (6) Cell 0016 represents the uranium zirconium hydride fuel that
c      constitutes the fueled region of the fuel element.
c  (7) Cell 0017 represents the molybdenum disk that separates the
c      fueled region of the fuel element from the graphite slug at
c      the lower end of the fuel element.
c  (8) Cell 0018 represents the graphite slug at the lower end of
c      the fuel element.
c  (9) Cell 0019 represents the stainless steel tri-flute at the lower
c      end of the fuel element.
c (10) Cell 0020 represents the reactor pool water that surrounds the
c      fuel element.
c
c     m        d                 geom           params
c     --   -----------  -----------------------  ------
0011  01  -8.00000E+00  ( -0012 -0004  0011 ) :
                        ( -0013 -0002  0012 )    u=1
0012  01  -8.00000E+00  -0011 -0004  0003  0006  u=1
0013  02  -1.20500E-03  -0011 -0003  0010        u=1
0014  03  -1.70000E+00  -0010 -0003  0009        u=1
0015  04  -6.50600E+00  -0009 -0001  0008        u=1
0016  05  -6.13115E+00  -0009 -0003  0001  0008  u=1
0017  06  -1.02200E+01  -0008 -0003  0007        u=1
0018  03  -1.70000E+00  -0007 -0003  0006        u=1
0019  01  -8.00000E+00  ( -0006 -0004  0194 ) :
                        ( -0194 -0002  0193 )    u=1
0020  07  -9.98207E-01  -0193 :
                        ( -0194  0002  0193 ) :
                        ( -0012  0004  0194 ) :
                        ( -0013  0002  0012 ) : 0013  u=1
c
c Cell cards modeling the fuel-followed control rod universe:
c ============================================================
c
c Fifteen cell cards are used to model the fuel-followed control rod universe:
c  (1) Cell 0031 represents the stainless steel fitting at the upper end of
c      the control rod.
c  (2) Cell 0032 represents the stainless steel cladding that covers the
c      outer cylindrical surfaces of the control rod.
c  (3) Cell 0033 represents the air gap at the upper end of the control rod.
c  (4) Cell 0034 represents the stainless steel plug that separates the air gap
c      at the upper end of the control rod from the boron carbide poison.
c  (5) Cell 0035 represents the air gap that surrounds the boron carbide poison.
c  (6) Cell 0036 represents the boron carbide poison.
c  (7) Cell 0037 represents the stainless steel plug that separates the boron
c      carbide poison from the air gap above the upper end of the fueled region
c      of the control rod.
c  (8) Cell 0038 represents the air gap above the upper end of the fueled
c      region of the control rod.
c  (9) Cell 0039 represents the zirconium rod that runs the length of the
c      fueled region of the control rod.
c (10) Cell 0040 represents the uranium zirconium hydride fuel that constitutes
c      the fueled region of the control rod.
c (11) Cell 0041 represents the stainless steel plug that separates the fueled
c      region of the control rod from the air gap at the lower end of the
c      control rod.
c (12) Cell 0042 represents the aluminum sleeve that surrounds the air gap at
c      the lower end of the control rod.
c (13) Cell 0043 represents the air gap at the lower end of the control rod.
c (14) Cell 0044 represents the stainless steel fitting at the lower end of
c      the control rod.
c (15) Cell 0045 represents the reactor pool water that surrounds the
c      control rod.
```

```
c
c     m        d                     geom                params
c     --   -----------  ------------------------------------  ------
0031  01  -8.00000E+00  -0036 -0025  0035                 u=2
0032  01  -8.00000E+00  -0035 -0025  0024  0027            u=2
0033  02  -1.20500E-03  -0035 -0024  0034                 u=2
0034  01  -8.00000E+00  -0034 -0024  0033                 u=2
0035  02  -1.20500E-03  -0033 -0024  0031 (  0022 :  0032 )  u=2
0036  08  -2.52000E+00  -0032 -0022  0031                 u=2
0037  01  -8.00000E+00  -0031 -0024  0030                 u=2
0038  02  -1.20500E-03  -0030 -0024  0008                 u=2
0039  04  -6.50600E+00  -0021 -0008  0029                 u=2
0040  05  -6.13115E+00  -0024 -0008  0021  0029            u=2
0041  01  -8.00000E+00  -0029 -0024  0028                 u=2
0042  09  -2.70000E+00  -0028 -0024  0023  0027            u=2
0043  02  -1.20500E-03  -0028 -0023  0027                 u=2
0044  01  -8.00000E+00  -0027 -0025  0026                 u=2
0045  07  -9.98207E-01  ( -0026 :  0025 :  0036 )          u=2
c
c Cell cards modeling the transient control rod universe:
c ===========================================================
c
c Eight cell cards are used to model the transient control rod universe:
c (1) Cell 0061 represents the aluminum fitting at the upper end of the
c     control rod.
c (2) Cell 0062 represents the aluminum cladding that covers the outer
c     cylindrical surfaces of the control rod.
c (3) Cell 0063 represents the air gap that surrounds the boron carbide poison.
c (4) Cell 0064 represents the boron carbide poison.
c (5) Cell 0065 represents the aluminum plug that separates the boron carbide
c     from the air-filled volume at the lower end of the control rod.
c (6) Cell 0066 represents the air-filled volume at the lower end of the
c     transient control rod. This air-filled volume replaces the zirconium
c     hydride fuel that constitutes the fueled region of the fuel-followed
c     control rod control rods.
c (7) Cell 0067 represents the aluminum fitting at the lower end of
c     the control rod.
c (8) Cell 0068 represents the reactor pool water that surrounds
c     the control rod.
c
c     m        d                  geom            params
c     --   -----------  -------------------------  ------
0061  09  -2.70000E+00  -0058 -0052  0057         u=3
0062  09  -2.70000E+00  -0058 -0053  0052  0054    u=3
0063  02  -1.20500E-03  -0057 -0052  0051  0056    u=3
0064  08  -2.52000E+00  -0057 -0051  0056         u=3
0065  09  -2.70000E+00  -0056 -0052  0008         u=3
0066  02  -1.20500E-03  -0052 -0008  0055         u=3
0067  09  -2.70000E+00  -0055 -0052  0054         u=3
0068  07  -9.98207E-01  ( -0054 :  0053 :  0058 )  u=3
c
c Cell cards modeling the fuel elements and control rods in the reactor core:
c ============================================================================
c
c 118 cell cards are used to model the fuel elements and control rods in the
c reactor core. 114 of the cell cards are used to model fuel elements. Three of
c the 114 cell cards (cell cards 0127, 0153, and 0154) are commented out when
c the 3L irradiation facility is in the reactor core. The other four cell cards
c (cell cards 0087, 0093, 0104, and 0112) are used to model the transient rod,
c the regulating rod, and the two shim rods, respectively.
c
c B-ring fuel element cells:
c --------------------------
c
c     m        geom            params
```

```
c     --  -----------------  -------------
0081  00  -0212 -0014  0005  FILL=1         $ Fuel element in location B01.
0082  00  -0213 -0014  0005  FILL=1 (0082)  $ Fuel element in location B02.
0083  00  -0214 -0014  0005  FILL=1 (0083)  $ Fuel element in location B03.
0084  00  -0215 -0014  0005  FILL=1 (0084)  $ Fuel element in location B04.
0085  00  -0216 -0014  0005  FILL=1 (0085)  $ Fuel element in location B05.
0086  00  -0217 -0014  0005  FILL=1 (0086)  $ Fuel element in location B06.
c
c C-ring fuel element and control rod cells:
c ------------------------------------------
c
c     m         geom            params
c     --  -----------------  -------------
0087  00  -0218 -0519  0518  FILL=3 (0087)  $ Transient rod in location C01.
0088  00  -0219 -0014  0005  FILL=1 (0088)  $ Fuel element in location C02.
0089  00  -0220 -0014  0005  FILL=1 (0089)  $ Fuel element in location C03.
0090  00  -0221 -0014  0005  FILL=1 (0090)  $ Fuel element in location C04.
0091  00  -0222 -0014  0005  FILL=1 (0091)  $ Fuel element in location C05.
0092  00  -0223 -0014  0005  FILL=1 (0092)  $ Fuel element in location C06.
0093  00  -0224 -0519  0518  FILL=2 (0093)  $ Regulating rod in location C07.
0094  00  -0225 -0014  0005  FILL=1 (0094)  $ Fuel element in location C08.
0095  00  -0226 -0014  0005  FILL=1 (0095)  $ Fuel element in location C09.
0096  00  -0227 -0014  0005  FILL=1 (0096)  $ Fuel element in location C10.
0097  00  -0228 -0014  0005  FILL=1 (0097)  $ Fuel element in location C11.
0098  00  -0229 -0014  0005  FILL=1 (0098)  $ Fuel element in location C12.
c
c D-ring fuel element and control rod cells:
c ------------------------------------------
c
c     m         geom            params
c     --  -----------------  -------------
0099  00  -0230 -0014  0005  FILL=1 (0099)  $ Fuel element in location D01.
0100  00  -0231 -0014  0005  FILL=1 (0100)  $ Fuel element in location D02.
0101  00  -0232 -0014  0005  FILL=1 (0101)  $ Fuel element in location D03.
0102  00  -0233 -0014  0005  FILL=1 (0102)  $ Fuel element in location D04.
0103  00  -0234 -0014  0005  FILL=1 (0103)  $ Fuel element in location D05.
0104  00  -0235 -0519  0518  FILL=2 (0104)  $ Shim rod 1 in location D06.
0105  00  -0236 -0014  0005  FILL=1 (0105)  $ Fuel element in location D07.
0106  00  -0237 -0014  0005  FILL=1 (0106)  $ Fuel element in location D08.
0107  00  -0238 -0014  0005  FILL=1 (0107)  $ Fuel element in location D09.
0108  00  -0239 -0014  0005  FILL=1 (0108)  $ Fuel element in location D10.
0109  00  -0240 -0014  0005  FILL=1 (0109)  $ Fuel element in location D11.
0110  00  -0241 -0014  0005  FILL=1 (0110)  $ Fuel element in location D12.
0111  00  -0242 -0014  0005  FILL=1 (0111)  $ Fuel element in location D13.
0112  00  -0243 -0519  0518  FILL=2 (0112)  $ Shim rod 2 in location D14.
0113  00  -0244 -0014  0005  FILL=1 (0113)  $ Fuel element in location D15.
0114  00  -0245 -0014  0005  FILL=1 (0114)  $ Fuel element in location D16.
0115  00  -0246 -0014  0005  FILL=1 (0115)  $ Fuel element in location D17.
0116  00  -0247 -0014  0005  FILL=1 (0116)  $ Fuel element in location D18.
c
c E-ring fuel element cells:
c --------------------------
c
c Note that the cell representing the fuel element in reactor
c core location E11, cell 0127, should be commented out
c if the 3L irradiation facility is in the reactor core.
c
c     m         geom            params
c     --  -----------------  -------------
0117  00  -0248 -0014  0005  FILL=1 (0117)  $ Fuel element in location E01.
0118  00  -0249 -0014  0005  FILL=1 (0118)  $ Fuel element in location E02.
0119  00  -0250 -0014  0005  FILL=1 (0119)  $ Fuel element in location E03.
0120  00  -0251 -0014  0005  FILL=1 (0120)  $ Fuel element in location E04.
0121  00  -0252 -0014  0005  FILL=1 (0121)  $ Fuel element in location E05.
0122  00  -0253 -0014  0005  FILL=1 (0122)  $ Fuel element in location E06.
```

```
0123  00  -0254 -0014  0005  FILL=1 (0123)  $ Fuel element in location E07.
0124  00  -0255 -0014  0005  FILL=1 (0124)  $ Fuel element in location E08.
0125  00  -0256 -0014  0005  FILL=1 (0125)  $ Fuel element in location E09.
0126  00  -0257 -0014  0005  FILL=1 (0126)  $ Fuel element in location E10.
c 0127  00  -0258 -0014  0005  FILL=1 (0127)  $ Fuel element in location E11.
0128  00  -0259 -0014  0005  FILL=1 (0128)  $ Fuel element in location E12.
0129  00  -0260 -0014  0005  FILL=1 (0129)  $ Fuel element in location E13.
0130  00  -0261 -0014  0005  FILL=1 (0130)  $ Fuel element in location E14.
0131  00  -0262 -0014  0005  FILL=1 (0131)  $ Fuel element in location E15.
0132  00  -0263 -0014  0005  FILL=1 (0132)  $ Fuel element in location E16.
0133  00  -0264 -0014  0005  FILL=1 (0133)  $ Fuel element in location E17.
0134  00  -0265 -0014  0005  FILL=1 (0134)  $ Fuel element in location E18.
0135  00  -0266 -0014  0005  FILL=1 (0135)  $ Fuel element in location E19.
0136  00  -0267 -0014  0005  FILL=1 (0136)  $ Fuel element in location E20.
0137  00  -0268 -0014  0005  FILL=1 (0137)  $ Fuel element in location E21.
0138  00  -0269 -0014  0005  FILL=1 (0138)  $ Fuel element in location E22.
0139  00  -0270 -0014  0005  FILL=1 (0139)  $ Fuel element in location E23.
0140  00  -0271 -0014  0005  FILL=1 (0140)  $ Fuel element in location E24.
c
c F-ring fuel element cells:
c -------------------------
c
c Note that the cells representing the fuel elements in reactor core
c locations F13 and F14, cells 0153 and 0154, respectively, should be
c commented out if the 3L irradiation facility is in the reactor core.
c
c     m        geom           params
c     --  -----------------  -------------
0141  00  -0272 -0014  0005  FILL=1 (0141)  $ Fuel element in location F01.
0142  00  -0273 -0014  0005  FILL=1 (0142)  $ Fuel element in location F02.
0143  00  -0274 -0014  0005  FILL=1 (0143)  $ Fuel element in location F03.
0144  00  -0275 -0014  0005  FILL=1 (0144)  $ Fuel element in location F04.
0145  00  -0276 -0014  0005  FILL=1 (0145)  $ Fuel element in location F05.
0146  00  -0277 -0014  0005  FILL=1 (0146)  $ Fuel element in location F06.
0147  00  -0278 -0014  0005  FILL=1 (0147)  $ Fuel element in location F07.
0148  00  -0279 -0014  0005  FILL=1 (0148)  $ Fuel element in location F08.
0149  00  -0280 -0014  0005  FILL=1 (0149)  $ Fuel element in location F09.
0150  00  -0281 -0014  0005  FILL=1 (0150)  $ Fuel element in location F10.
0151  00  -0282 -0014  0005  FILL=1 (0151)  $ Fuel element in location F11.
0152  00  -0283 -0014  0005  FILL=1 (0152)  $ Fuel element in location F12.
c 0153  00  -0284 -0014  0005  FILL=1 (0153)  $ Fuel element in location F13.
c 0154  00  -0285 -0014  0005  FILL=1 (0154)  $ Fuel element in location F14.
0155  00  -0286 -0014  0005  FILL=1 (0155)  $ Fuel element in location F15.
0156  00  -0287 -0014  0005  FILL=1 (0156)  $ Fuel element in location F16.
0157  00  -0288 -0014  0005  FILL=1 (0157)  $ Fuel element in location F17.
0158  00  -0289 -0014  0005  FILL=1 (0158)  $ Fuel element in location F18.
0159  00  -0290 -0014  0005  FILL=1 (0159)  $ Fuel element in location F19.
0160  00  -0291 -0014  0005  FILL=1 (0160)  $ Fuel element in location F20.
0161  00  -0292 -0014  0005  FILL=1 (0161)  $ Fuel element in location F21.
0162  00  -0293 -0014  0005  FILL=1 (0162)  $ Fuel element in location F22.
0163  00  -0294 -0014  0005  FILL=1 (0163)  $ Fuel element in location F23.
0164  00  -0295 -0014  0005  FILL=1 (0164)  $ Fuel element in location F24.
0165  00  -0296 -0014  0005  FILL=1 (0165)  $ Fuel element in location F25.
0166  00  -0297 -0014  0005  FILL=1 (0166)  $ Fuel element in location F26.
0167  00  -0298 -0014  0005  FILL=1 (0167)  $ Fuel element in location F27.
0168  00  -0299 -0014  0005  FILL=1 (0168)  $ Fuel element in location F28.
0169  00  -0300 -0014  0005  FILL=1 (0169)  $ Fuel element in location F29.
0170  00  -0301 -0014  0005  FILL=1 (0170)  $ Fuel element in location F30.
c
c G-ring fuel element cells:
c -------------------------
c
c Note that there are no fuel element cells associated with the G01, G07, G13,
c G19, G25, or G31 reactor core locations because there are not cutouts in the
c top or bottom grid plates in any of these reactor core locations. Reactor
```

```
c core locations G32 and G34 sometimes contain the AmBe startup source and the
c pneumatic transfer system irradiation facility, respectively, depending on
c the reactor core configuration. When the G32 and G34 reactor core locations
c do not contain the AmBe startup source or the pneumatic transfer system
c irradiation facility they are typically left empty (i.e. they are filled
c with water, not fuel elements).
c
c     m        geom           params
c     --  -----------------  -------------
0171  00  -0302 -0014  0005  FILL=1 (0171)  $ Fuel element in location G02.
0172  00  -0303 -0014  0005  FILL=1 (0172)  $ Fuel element in location G03.
0173  00  -0304 -0014  0005  FILL=1 (0173)  $ Fuel element in location G04.
0174  00  -0305 -0014  0005  FILL=1 (0174)  $ Fuel element in location G05.
0175  00  -0306 -0014  0005  FILL=1 (0175)  $ Fuel element in location G06.
0176  00  -0307 -0014  0005  FILL=1 (0176)  $ Fuel element in location G08.
0177  00  -0308 -0014  0005  FILL=1 (0177)  $ Fuel element in location G09.
0178  00  -0309 -0014  0005  FILL=1 (0178)  $ Fuel element in location G10.
0179  00  -0310 -0014  0005  FILL=1 (0179)  $ Fuel element in location G11.
0180  00  -0311 -0014  0005  FILL=1 (0180)  $ Fuel element in location G12.
0181  00  -0312 -0014  0005  FILL=1 (0181)  $ Fuel element in location G14.
0182  00  -0313 -0014  0005  FILL=1 (0182)  $ Fuel element in location G15.
0183  00  -0314 -0014  0005  FILL=1 (0183)  $ Fuel element in location G16.
0184  00  -0315 -0014  0005  FILL=1 (0184)  $ Fuel element in location G17.
0185  00  -0316 -0014  0005  FILL=1 (0185)  $ Fuel element in location G18.
0186  00  -0317 -0014  0005  FILL=1 (0186)  $ Fuel element in location G20.
0187  00  -0318 -0014  0005  FILL=1 (0187)  $ Fuel element in location G21.
0188  00  -0319 -0014  0005  FILL=1 (0188)  $ Fuel element in location G22.
0189  00  -0320 -0014  0005  FILL=1 (0189)  $ Fuel element in location G23.
0190  00  -0321 -0014  0005  FILL=1 (0190)  $ Fuel element in location G24.
0191  00  -0322 -0014  0005  FILL=1 (0191)  $ Fuel element in location G26.
0192  00  -0323 -0014  0005  FILL=1 (0192)  $ Fuel element in location G27.
0193  00  -0324 -0014  0005  FILL=1 (0193)  $ Fuel element in location G28.
0194  00  -0325 -0014  0005  FILL=1 (0194)  $ Fuel element in location G29.
0195  00  -0326 -0014  0005  FILL=1 (0195)  $ Fuel element in location G30.
0196  00  -0328 -0014  0005  FILL=1 (0196)  $ Fuel element in location G33.
0197  00  -0330 -0014  0005  FILL=1 (0197)  $ Fuel element in location G35.
0198  00  -0331 -0014  0005  FILL=1 (0198)  $ Fuel element in location G36.
c
c Cell cards modeling the central thimble irradiation facility:
c ================================================================
c
c Five cell cards are used to model the central thimble irradiation facility:
c (1) Cell 0221 represents the plug at the bottom of the central thimble
c     irradiation facility.
c (2) Cell 0222 represents the cylindrical walls of the central thimble
c     irradiation facility.
c (3) Cell 0223 represents the water-filled volume inside the lower portion of
c     the central thimble irradiation facility. Note that there are holes in
c     the cylindrical walls of the central thimble irradiation facility that
c     prevent the lower portion of the central thimble below the upper grid
c     plate from being blown dry and filled with air even when the central
c     thimble irradiation is blown dry to support sample irradiations.
c (4) Cell 0224 represents the air/water-filled volume inside the upper portion
c     of the central thimble irradiation facility. Note that the upper portion
c     of the central thimble irradiation facility may be blown dry and filled
c     with air to support sample irradiations and that switching the between the
c     air-filled volume and the water-filled volume is as simple as modifying
c     the material number on cell card 0224; set the material number to the
c     material number associated with the air material data card to select the
c     air-filled volume, or set the material number to the material number
c     associated with the water material data card to select the
c     water-filled volume.
c (5) Cell 0225 represents the sample location within the air/water-filled
c     volume inside the central thimble irradiation facility. As is the case
c     with cell card 0224, note that switching the between the air-filled volume
```

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c     inside the central thimble irradiation facility and the water-filled
c     volume inside the central thimble irradiation facility is as simple as
c     modifying the material number on cell card 0225.
c
c     m         d                    geom
c     --   -----------  -----------------------------
0221  09  -2.70000E+00  -0075 -0072  0074
0222  09  -2.70000E+00  -0519 -0073  0072  0074
0223  07  -9.98207E-01  -0519 -0078 -0072  0075 #0225
0224  07  -9.98207E-01  -0519 -0072  0078
0225  07  -9.98207E-01  -0077 -0071  0076
c
c Cell cards modeling the three element (3L) irradiation facility universe:
c ==========================================================================
c
c Seven cell cards are used to model the 3L irradiation facility universe:
c (1) Cell 0231 represents the outer aluminum casing of
c     the 3L irradiation facility.
c (2) Cell 0232 represents the air gap between the outer aluminum casing
c     and the cadmium/lead sleeve of the 3L irradiation facility.
c (3) Cell 0233 represents the cadmium/lead sleeve of the 3L irradiation
c     facility. Note that switching between the cadmium 3L irradiation facility
c     sleeve and the lead 3L irradiation facility sleeve is as simple as
c     modifying the material number on cell card 0233; set the material number
c     to the material number associated with the cadmium material data card to
c     select the cadmium 3L irradiation facility sleeve, or set the material
c     number to the material number associated with the lead material data
c     card to select the lead 3L irradiation facility sleeve.
c (4) Cell 0234 represents the aluminum sleeve between the cadmium/lead sleeve
c     of the 3L irradiation facility and the inner CO2-purged volume of the
c     3L irradiation facility where samples are located.
c (5) Cell 0235 represents the inner CO2-purged volume of the 3L irradiation
c     facility where samples are located. Note that in this model the inner
c     CO2-purged volume is actually filled with air rather than CO2.
c (6) Cell 0236 represents the reactor pool water that surrounds
c     the 3L irradiation facility.
c (7) Cell 0237 is a cylindrical cell centered at a location corresponding
c     to the position of the 3L irradiation facility in the reactor core.
c     This cell is filled with the 3L irradiation facility universe,
c     effectively placing the 3L irradiation facility in the appropriate
c     location within the reactor core.
c
c     m         d                   geom              params
c     --   -----------  -------------------------  ------
c 0231  09  -2.70000E+00  -0094 -0085  0087
c                       (  0084 :  0093 : -0088 )  u=4
0796   09  -2.70000E+00  -0747  0716   u=4
0797   24  -8.65000E+00  -0748  0751      u=4
c 0798   27  -1.04900E+01  -0749  0752  0750       u=4
0799   09  -2.70000E+00  -0789  0788  0790  0742   u=4
0800   09  -2.70000E+00  -0788  0790         u=4
0801   02  -1.20500E-03  -0790  0748  0751
                  0755  0777  0754
                  0753  0742  0716  0747
                  0744   u=4
0696  09  -2.70000E+00  -0742  0741  0744  0716       u=4
0699  08  -1.46000E+00  -0741  0744            u=4
0700  09  -2.70000E+00  -0744  0716            u=4
0701  09  -2.70000E+00  -0716  0715            u=4
0702  02  -1.20500E-03  -0715  0714            u=4
0703  09  -2.70000E+00  -0714  0713            u=4
0704  02  -1.20500E-03  -0713  0712            u=4
0705  25  -2.20300E+00  -0712  0711            u=4
0706  02  -1.20500E-05  -0711                  u=4
0707  09  -2.70000E+00  -0751  0750  0752  0747  u=4
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0708  22  -1.55000E+00  -0750  0747  u=4
0709  22  -1.55000E+00  -0752  0747  u=4
0710  27  -1.04900E+01  -0753           u=4
0711  24  -8.65000E+00  -0754           u=4
0712  09  -2.70000E+00  -0755  0766      u=4
0713  02  -1.20500E-03  -0766           u=4
0714  09  -2.70000E+00  -0777           u=4
c the above 0700+ are for the macrobody definitions
c 0232  02  -1.20500E-03  -0093 -0084  0081  0088
c                  (  0083 :  0091 )
c                  (  0082 :  0092 )        u=4
c 0233  10  -1.13500E+01  -0091 -0083  0088
c                  ( -0089 :  0082 )        u=4
c 0234  09  -2.70000E+00  -0092 -0082  0089
c                   ( -0090 :  0081 )        u=4
c 0235  02  -1.20500E-03  -0093 -0081  0090
c                   #0256 #0257 #0255 #0254
c                  #0253 #0252 #0251        u=4
0236  07  -9.98207E-01  (  0094 : -0087 : 0788 ) 0789  u=4
0237  00              -0519 -0086  0194        FILL=4
c
c Cell cards modeling the Swagelok PFA plug
c valve in the 3L irradiation facility:
c ==========================================
c
c Seven cell cards are used to model the Swagelok PFA plug valve
c in the 3L irradiation facility:
c (1) Cell 0251 represents the Ar, Xe, etc. gas trapped
c    in the Swagelok PFA plug valve end-cap section.
c (2) Cell 0252 represents the PFA portion of the bottom end
c    of the Swagelok PFA plug valve that has an end-cap on
c    it to trap the Ar, Xe, etc. gas to be irradiated.
c (3) Cell 0253 represents the Ar, Xe, etc. gas trapped in
c    the Swagelok PFA plug valve central body section.
c (4) Cell 0254 represents the thin PFA portion of the
c    Swagelok PFA plug valve central body section.
c (5) Cell 0255 represents the thick PFA portion of the
c    Swagelok PFA plug valve central body section.
c (6) Cell 0256 represents the open portion of the top end of the
c    Swagelok PFA plug valve that has no end-cap on it and is open
c    to the CO2 purge gas in the 3L irradiation facility.
c (7) Cell 0257 represents the PFA portion of the top end of the
c    Swagelok PFA plug valve that has no end-cap on it and is open
c    to the CO2 purge gas in the 3L irradiation facility.
c
c    m       d                  geom               params
c    --   -----------  -----------------------------------  ------
c 0251  12   3.29400E-06  ( -0113 -0104  0102  0112 ) :
c                  ( -0113 -0112 -0105  0111 )        u=4
c 0252  11  -2.15000E+00  ( -0113 -0105  0103  0104  0112 ) :
c                  ( -0113 -0107  0103  0105  0111 ) :
c                  ( -0113 -0111 -0107  0090 )        u=4
c 0253  12   3.29400E-06  -0102 -0101                    u=4
c 0254  11  -2.15000E+00  ( -0110 -0102  0108 ) #0253        u=4
c 0255  11  -2.15000E+00  -0109 -0103  0102  0108 #0256 #0251  u=4
c 0256  02  -1.20500E-03  ( -0114 -0104  0102  0113 ) :
c                  ( -0115 -0105  0113  0114 )        u=4
c 0257  11  -2.15000E+00  ( -0114 -0105  0103  0104  0113 ) :
c                  ( -0115 -0106  0103  0105  0113 )    u=4
c
c Cell cards modeling the pneumatic transfer system irradiation facility:
c ==========================================================================
c
c Five cell cards are used to model the pneumatic
c transfer system irradiation facility:
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```
c (1) Cell 0271 represents the air cavity at the interior of the
c     pneumatic transfer system irradiation facility.
c (2) Cell 0272 represents the aluminum sleeve between the air cavity at
c     the interior of the pneumatic transfer system irradiation facility
c     and the cadmium/lead sleeve of the pneumatic transfer system
c     irradiation facility.
c (3) Cell 0273 represents the cadmium/lead sleeve of the pneumatic
c     transfer system irradiation facility. Note that switching between the
c     cadmium pneumatic transfer system irradiation facility sleeve and the
c     lead pneumatic transfer system irradiation facility sleeve is as simple
c     as modifying the material number on cell card 0273; set the material
c     number to the material number associated with the cadmium material
c     data card to select the cadmium pneumatic transfer system irradiation
c     facility sleeve, or set the material number to the material number
c     associated with the lead material data card to select the lead
c     pneumatic transfer system irradiation facility sleeve.
c (4) Cell 0274 represents the air gap between the cadmium/lead sleeve
c     and the outer aluminum casing of the pneumatic transfer system
c     irradiation facility.
c (5) Cell 0275 represents the outer aluminum casing of the pneumatic
c     transfer system irradiation facility.
c
c It should be noted that the pneumatic transfer system irradiation facility is
c only modeled to a height of 50 cm above the vertical center of the reactor
c core, but in reality it extends all the way to the surface of the reactor pool.
c
c     m   d              geom
c     --  -----------  -----------------------------------
c 0271  02  -1.20500E-03  -0131 -0121  0130
c 0272  09  -2.70000E+00  -0131 -0122  0129 ( -0130 :  0121 )
c 0273  13  -8.65000E+00  -0131 -0123  0128 ( -0129 :  0122 )
c 0274  02  -1.20500E-03  -0131 -0124  0127 ( -0128 :  0123 )
c 0275  09  -2.70000E+00  -0131 -0125  0126 ( -0127 :  0124 )
c
c Cell cards modeling the Rotary Specimen Rack (RSR):
c ==================================================
c
c Cell cards modeling the outer casing and inner volume of the RSR:
c -----------------------------------------------------------------
c
c Two cell cards are used to model the outer casing and inner volume of the RSR:
c (1) Cell 0291 represents the outer casing of the RSR.
c (2) Cell 0292 represents the inner volume of the RSR where the sample tubes
c     are located.
c
c     m   d                geom
c     --  -----------  -----------------------------------------------
0293  09  -2.70000E+00  ( -0152 -0142  0141  0149 )
0291  09  -2.70000E+00  ( -0150 -0143  0142  0149 ) :
                  ( -0150 -0144  0143  0147 ) :
                  ( -0148 -0145  0144  0147 ) :
                  ( -0152 -0146  0145  0147 ) :
                  ( -0145  0142  0151 -0152 )
0292  02  -1.20500E-03  ( -0151 -0144  0142  0150 ) :
                  ( -0151 -0145  0148  0144 )
                  #0301 #0302 #0303 #0304 #0305 #0306 #0307 #0308
                  #0309 #0310 #0311 #0312 #0313 #0314 #0315 #0316
                  #0317 #0318 #0319 #0320 #0321 #0322 #0323 #0324
                  #0325 #0326 #0327 #0328 #0329 #0330 #0331 #0332
                  #0333 #0334 #0335 #0336 #0337 #0338 #0339 #0340
                  #0351 #0352 #0353 #0354
c
c Cell cards modeling the RSR sample tubes:
c ----------------------------------------
c
```

```
c 40 cell cards, cell cards 0301 through 0340, are used to model the 40 RSR
c sample tubes. MCNP cell card form 1 is used on cell card 0301 to model RSR
c sample tube 01 and MCNP cell card form 2 is used on cell cards 0302 through
c 0340 to model RSR sample tubes 02 through 40.
c
c    m        d                    geom
c    --   -----------  -----------------------------------
0301  09  -2.70000E+00  -0165 -0161  0163 ( -0164 :  0162 )  $ Sample tube 01.
c
c    LIKE   n    BUT                    list
c    ----  ----  ---  ---------------------------------------------
0302  like  0301  but  TRCL=(-4.11900E-01  5.23371E+00  0.00000E+00)  $ Tube 02.
0303  like  0301  but  TRCL=(-1.63747E+00  1.03386E+01  0.00000E+00)  $ Tube 03.
0304  like  0301  but  TRCL=(-3.64652E+00  1.51888E+01  0.00000E+00)  $ Tube 04.
0305  like  0301  but  TRCL=(-6.38958E+00  1.96651E+01  0.00000E+00)  $ Tube 05.
0306  like  0301  but  TRCL=(-9.79912E+00  2.36572E+01  0.00000E+00)  $ Tube 06.
0307  like  0301  but  TRCL=(-1.37912E+01  2.70667E+01  0.00000E+00)  $ Tube 07.
0308  like  0301  but  TRCL=(-1.82675E+01  2.98098E+01  0.00000E+00)  $ Tube 08.
0309  like  0301  but  TRCL=(-2.31177E+01  3.18188E+01  0.00000E+00)  $ Tube 09.
0310  like  0301  but  TRCL=(-2.82226E+01  3.30444E+01  0.00000E+00)  $ Tube 10.
0311  like  0301  but  TRCL=(-3.34563E+01  3.34563E+01  0.00000E+00)  $ Tube 11.
0312  like  0301  but  TRCL=(-3.86900E+01  3.30444E+01  0.00000E+00)  $ Tube 12.
0313  like  0301  but  TRCL=(-4.37949E+01  3.18188E+01  0.00000E+00)  $ Tube 13.
0314  like  0301  but  TRCL=(-4.86451E+01  2.98098E+01  0.00000E+00)  $ Tube 14.
0315  like  0301  but  TRCL=(-5.31214E+01  2.70667E+01  0.00000E+00)  $ Tube 15.
0316  like  0301  but  TRCL=(-5.71135E+01  2.36572E+01  0.00000E+00)  $ Tube 16.
0317  like  0301  but  TRCL=(-6.05230E+01  1.96651E+01  0.00000E+00)  $ Tube 17.
0318  like  0301  but  TRCL=(-6.32661E+01  1.51888E+01  0.00000E+00)  $ Tube 18.
0319  like  0301  but  TRCL=(-6.52751E+01  1.03386E+01  0.00000E+00)  $ Tube 19.
0320  like  0301  but  TRCL=(-6.65007E+01  5.23372E+00  0.00000E+00)  $ Tube 20.
0321  like  0301  but  TRCL=(-6.69126E+01  0.00000E+00  0.00000E+00)  $ Tube 21.
0322  like  0301  but  TRCL=(-6.65007E+01 -5.23372E+00  0.00000E+00)  $ Tube 22.
0323  like  0301  but  TRCL=(-6.52751E+01 -1.03386E+01  0.00000E+00)  $ Tube 23.
0324  like  0301  but  TRCL=(-6.32661E+01 -1.51888E+01  0.00000E+00)  $ Tube 24.
0325  like  0301  but  TRCL=(-6.05230E+01 -1.96651E+01  0.00000E+00)  $ Tube 25.
0326  like  0301  but  TRCL=(-5.71135E+01 -2.36572E+01  0.00000E+00)  $ Tube 26.
0327  like  0301  but  TRCL=(-5.31214E+01 -2.70667E+01  0.00000E+00)  $ Tube 27.
0328  like  0301  but  TRCL=(-4.86451E+01 -2.98098E+01  0.00000E+00)  $ Tube 28.
0329  like  0301  but  TRCL=(-4.37949E+01 -3.18188E+01  0.00000E+00)  $ Tube 29.
0330  like  0301  but  TRCL=(-3.86900E+01 -3.30444E+01  0.00000E+00)  $ Tube 30.
0331  like  0301  but  TRCL=(-3.34563E+01 -3.34563E+01  0.00000E+00)  $ Tube 31.
0332  like  0301  but  TRCL=(-2.82226E+01 -3.30444E+01  0.00000E+00)  $ Tube 32.
0333  like  0301  but  TRCL=(-2.31177E+01 -3.18188E+01  0.00000E+00)  $ Tube 33.
0334  like  0301  but  TRCL=(-1.82675E+01 -2.98098E+01  0.00000E+00)  $ Tube 34.
0335  like  0301  but  TRCL=(-1.37912E+01 -2.70667E+01  0.00000E+00)  $ Tube 35.
0336  like  0301  but  TRCL=(-9.79912E+00 -2.36572E+01  0.00000E+00)  $ Tube 36.
0337  like  0301  but  TRCL=(-6.38958E+00 -1.96651E+01  0.00000E+00)  $ Tube 37.
0338  like  0301  but  TRCL=(-3.64652E+00 -1.51888E+01  0.00000E+00)  $ Tube 38.
0339  like  0301  but  TRCL=(-1.63747E+00 -1.03386E+01  0.00000E+00)  $ Tube 39.
0340  like  0301  but  TRCL=(-4.11900E-01 -5.23372E+00  0.00000E+00)  $ Tube 40.
c
c Cell cards modeling the cobalt RSR flux wires:
c =============================================
c
c Four cell cards, cell cards 0351, 0352, 0353, and 0354, are used to model four
c cobalt RSR flux wires, one in each of four rotary specimen rack sample tubes.
c
c    m        d             geom
c    --   -----------  -----------------
0351  14  -8.90000E+00  -0176 -0171  0175
0352  14  -8.90000E+00  -0176 -0174  0175
0353  14  -8.90000E+00  -0176 -0173  0175
0354  14  -8.90000E+00  -0176 -0172  0175
c
c Cell cards modeling the top and bottom grid plates:
```

```
c ====================================================
c
c One cell card, cell card 0361, is used to model the bottom grid plate,
c and one card, cell card 0371, is used to model the top grid plate.
c
c     m        d                        geom
c     --   -----------  ----------------------------------------------
0361  09  -2.70000E+00  -0194 -0192 -0191 -0189 -0188 -0186 -0185 -0184
                  -0183 -0182 -0181  0187  0190  0193  0211  0212
                   0213  0214  0215  0216  0217  0218  0219  0220
                   0221  0222  0223  0224  0225  0226  0227  0228
                   0229  0230  0231  0232  0233  0234  0235  0236
                   0237  0238  0239  0240  0241  0242  0243  0244
                   0245  0246  0247  0248  0249  0250  0251  0252
                   0253  0254  0255  0256  0257  0258  0259  0260
                   0261  0262  0263  0264  0265  0266  0267  0268
                   0269  0270  0271  0272  0273  0274  0275  0276
                   0277  0278  0279  0280  0281  0282  0283  0284
                   0285  0286  0287  0288  0289  0290  0291  0292
                   0293  0294  0295  0296  0297  0298  0299  0300
                   0301  0302  0303  0304  0305  0306  0307  0308
                   0309  0310  0311  0312  0313  0314  0315  0316
                   0317  0318  0319  0320  0321  0322  0323  0324
                   0325  0326  0327  0328  0329  0330  0331  0351
                   0352  0353  0354  0355  0356  0357  0358  0359
                   0360  0371  0372  0373  0374  0375  0376  0377
                   0378  0379  0380  0381  0382  0383  0384  0385
                   0386  0387  0388  0389  0390  0391  0392  0393
                   0394  0395
0371  09  -2.70000E+00  -0202 -0200  0086  0201  0211  0212  0213  0214
                   0215  0216  0217  0218  0219  0220  0221  0222
                   0223  0224  0225  0226  0227  0228  0229  0230
                   0231  0232  0233  0234  0235  0236  0237  0238
                   0239  0240  0241  0242  0243  0244  0245  0246
                   0247  0248  0249  0250  0251  0252  0253  0254
                   0255  0256  0257        0259  0260  0261  0262
                   0263  0264  0265  0266  0267  0268  0269  0270
                   0271  0272  0273  0274  0275  0276  0277  0278
                   0279  0280  0281  0282  0283              0286
                   0287  0288  0289  0290  0291  0292  0293  0294
                   0295  0296  0297  0298  0299  0300  0301  0302
                   0303  0304  0305  0306  0307  0308  0309  0310
                   0311  0312  0313  0314  0315  0316  0317  0318
                   0319  0320  0321  0322  0323  0324  0325  0326
                   0327  0328  0329  0330  0331  0371  0372  0373
                   0374  0375  0376  0377  0378  0379  0380  0381
                   0382  0383  0384  0385  0386  0387  0388  0389
                   0390  0391  0392  0393  0394  0395  0411  0412
                   0413  0414  0415  0416  0417  0418  0419  0420
c
c Cell cards modeling the reactor reflector assembly:
c ====================================================
c
c Fifteen cell cards are used to model the reactor reflector assembly:
c  (1) Cell 0381 represents the aluminum shroud on the top surface of the
c      reactor reflector assembly.
c  (2) Cell 0382 represents the thick portion of the aluminum shroud on the top
c      surface of the reactor reflector assembly where the top grid plate and
c      the rotary specimen rack attach to the reactor reflector assembly.
c  (3) Cell 0383 represents the recessed portion of the aluminum shroud on the
c      top surface of the reactor reflector assembly where the rotary specimen
c      rack rests inside the upper portion of the reactor reflector assembly.
c  (4) Cell 0384 represents the air gap that fills the upper portion of the
c      reactor reflector assembly between the rotary specimen rack and the
c      aluminum shroud on the inner cylindrical surface of the reactor
```

```
c      reflector assembly.
c  (5) Cell 0385 represents the aluminum shroud on the inner cylindrical
c      surface of the reactor reflector assembly.
c  (6) Cell 0386 represents the aluminum shroud on the outer cylindrical
c      surface of the reactor reflector assembly.
c  (7) Cell 0387 represents the graphite that fills the reactor
c      reflector assembly.
c  (8) Cell 0388 represents the aluminum shroud that surrounds the water-filled
c      cavity that runs parallel to beam port 2 in the reactor
c      reflector assembly.
c  (9) Cell 0389 represents the water-filled cavity that runs parallel to
c      beam port 2 in the reactor reflector assembly.
c (10) Cell 0390 represents the aluminum shroud that surrounds the water-filled
c      sleeve that surrounds the portion of beam port 3 that extends into the
c      the reactor reflector assembly.
c (11) Cell 0391 represents the water-filled sleeve that surrounds the portion
c      of beam port 3 that extends into the reactor reflector assembly.
c (12) Cell 0392 represents the aluminum shroud that surrounds the water-filled
c      cavity that runs parallel to beam port 4 in the reactor
c      reflector assembly.
c (13) Cell 0393 represents the water-filled cavity that runs parallel to
c      beam port 4 in the reactor reflector assembly.
c (14) Cell 0394 represents the aluminum shroud on the
c      bottom surface of the reactor reflector assembly.
c (15) Cell 0395 represents the lip that extends downward from the outer
c      edges of the aluminum shroud on the bottom surface of the reactor
c      reflector assembly.
c
c     m        d                          geom
c     --   -----------  -------------------------------------------------
0381  09  -2.70000E+00  -0480 -0451  0474  0479
0382  09  -2.70000E+00  -0478 -0472  0477
                    ( -0201 :  0200 ) ( -0471 :  0443 )
                    ( -0190 : -0187 :  0181 :  0182 :
                      0183 :  0184 :  0185 :  0186 :
                      0188 :  0189 :  0191 :  0192 ) #0385
0383  09  -2.70000E+00  -0474 -0443  0471  0475
                    ( -0476 : -0472 :  0473 )
0384  02  -1.20500E-03  -0477 -0471  0475
                    ( -0440 : -0437 :  0431 :  0432 :  0433 :
                      0434 :  0435 :  0436 :  0438 :  0439 :
                      0441 :  0442 )
0385  09  -2.70000E+00  -0443  0193
                    ( -0442 -0441 -0439 -0438 -0436 -0435
                     -0434 -0433 -0432 -0431  0437  0440 )
                    ( -0190 : -0187 :  0181 :  0182 :  0183 :
                      0184 :  0185 :  0186 :  0188 :  0189 :
                      0191 :  0192 )
0386  09  -2.70000E+00  -0454 -0452  0451  0453  0562
                    (  0437 :  0492 )
0387  03  -1.70000E+00  -0479 -0451  0462  0562
                    ( -0475 :  0474 ) (  0437 :  0492 )
                    ( -0439 :  0652 ) (  0612 :  0615 )
                    ( -0504 : -0502 : -0431 :  0501 :  0503 :  0505 )
                    ( -0440 : -0437 :  0431 :  0432 :  0433 :
                      0434 :  0435 :  0436 :  0438 :  0439 :
                      0441 :  0442 )
0388  09  -2.70000E+00  -0615 -0612 -0451  0611
0389  07  -9.98207E-01  -0615 -0611 -0451
0390  09  -2.70000E+00  -0492 -0452 -0437  0491
0391  07  -9.98207E-01  -0491 -0452 -0437  0632
0392  09  -2.70000E+00  -0652 -0451  0439  0651
0393  07  -9.98207E-01  -0651 -0451  0439  0664
0394  09  -2.70000E+00  -0462 -0451  0461
                    ( -0440 : -0437 :  0431 :  0432 :  0433 :  0434 :
```

```
                 0435 :  0436 :  0438 :  0439 :  0441 :  0442 )
0395  09  -2.70000E+00  -0461 -0451  0193  0463
c
c Cell cards modeling the reactor pool water:
c ==========================================
c
c Three cell cards are used to model the reactor pool water in a piecewise
c fashion: (1) Cell 0411 is used to model the fraction of the reactor pool water
c in the cylindrical column shared by the reactor core. (2) Cell 0412 is used
c to model the largest fraction of the reactor pool water, the fraction of the
c pool water that is not in the cylindrical column shared by the reactor core.
c This fraction of the reactor pool water is modeled as two large cylinders that
c extend out to the curved sections of the aluminum pool liner. (3) Cell 0413
c is used to model the remainder of the reactor pool water, the fraction that
c extends out from the outer edges of the two cylinders associated with
c cell 0412 to the straight sections of the aluminum pool liner.
c
c     m        d                        geom
c     --   -----------  -----------------------------------------------
0411  07  -9.98207E-01  -0519 -0511  0518 #0081 #0082 #0083 #0084 #0085
                #0086 #0087 #0088 #0089 #0090 #0091 #0092 #0093
                #0094 #0095 #0096 #0097 #0098 #0099 #0100 #0101
                #0102 #0103 #0104 #0105 #0106 #0107 #0108 #0109
                #0110 #0111 #0112 #0113 #0114 #0115 #0116 #0117
                #0118 #0119 #0120 #0121 #0122 #0123 #0124 #0125
                #0126 #0128 #0129 #0130 #0131 #0132 #0133 #0134
                #0135 #0136 #0137 #0138 #0139 #0140 #0141 #0142
                #0143 #0144 #0145 #0146 #0147 #0148 #0149 #0150
                #0151 #0152 #0155 #0156 #0157 #0158 #0159 #0160
                #0161 #0162 #0163 #0164 #0165 #0166 #0167 #0168
                #0169 #0170 #0171 #0172 #0173 #0174 #0175 #0176
                #0177 #0178 #0179 #0180 #0181 #0182 #0183 #0184
                #0185 #0186 #0187 #0188 #0189 #0190 #0191 #0192
                #0193 #0194 #0195 #0196 #0197 #0198 #0221 #0222
                #0223 #0224 #0225 #0237
                    #0361 #0371 #0381 #0382 #0383 #0384 #0385
                #0387 #0390 #0391 #0392 #0393 #0394 #0395 #0441
                #0451 #0471 #0472 #0491 #0492
0412  07  -9.98207E-01  ( -0513 : -0512 ) -0519  0511  0518
                #0291 #0292 #0293 #0301 #0302 #0303 #0304 #0305 #0306
                #0307 #0308 #0309 #0310 #0311 #0312 #0313 #0314
                #0315 #0316 #0317 #0318 #0319 #0320 #0321 #0322
                #0323 #0324 #0325 #0326 #0327 #0328 #0329 #0330
                #0331 #0332 #0333 #0334 #0335 #0336 #0337 #0338
                #0339 #0340 #0351 #0352 #0353 #0354 #0371 #0381
                #0382 #0383 #0384 #0385 #0386 #0387 #0388 #0389
                #0390 #0391 #0392 #0393 #0394 #0395 #0441 #0442
                #0451 #0461 #0462 #0471 #0472 #0491 #0492 #0501
                #0502 #0503 #0504 #0505
0413  07  -9.98207E-01  -0519 -0517 -0515  0512  0513  0514  0516  0518
                #0441 #0442
c
c Cell cards modeling the pool liner:
c ==================================
c
c A single cell card, cell card 0421, is used to model the aluminum reactor
c pool liner that lines the inner surfaces of the biological shield and
c separates the biological shield from the reactor pool water. The cell
c consists of four sections: (1) Section 1 is the curved section of the
c reactor pool liner that lines the southern edge of the biological shield.
c (2) Section 2 is the straight section of the reactor pool liner that lines
c the eastern edge the biological shield. (3) Section 3 is the curved section
c of the reactor pool liner that lines the northern edge of the biological
c shield. (4) Section 4 is the straight section of the reactor pool liner
c that lines the western edge of the biological shield.
```

```
c
c     m         d                              geom
c     --   -----------   -----------------------------------------------------
0421  09  -2.70000E+00  ( -0532 -0519  0513  0515  0518 ) :
                        ( -0534 -0519 -0515  0514  0517  0518  0562 ) :
                        ( -0531 -0519 -0514  0512  0518  0612  0632  0652 ) :
                        ( -0519 -0516 -0515  0514  0518  0533  0562 )
c
c Cell cards modeling the biological shield:
c ==========================================
c
c Six cell cards are used to model the biological shield:
c (1) Cell 0431 represents the cylindrical portion of the biological shield
c     that surrounds beam port 1.
c (2) Cell 0432 represents the cylindrical portion of the biological shield
c     that surrounds beam port 2.
c (3) Cell 0433 represents the cylindrical portion of the biological shield
c     that surrounds beam port 3.
c (4) Cell 0434 represents the cylindrical portion of the biological shield
c     that surrounds beam port 4.
c (5) Cell 0435 represents the cylindrical portion of the biological shield
c     that surrounds beam port 5.
c (6) Cell 0436 represents the remainder of the biological shield.
c
c     m         d                              geom
c     --   -----------  -----------------------------------------------------
0431  15  -2.89000E+00  -0553 -0544  0534 #0441 #0442 #0443 #0444
0432  15  -2.89000E+00  -0615 -0554 -0546  0531 #0461 #0462 #0463 #0464 #0465
0433  15  -2.89000E+00  -0555 -0514  0531  0547 #0471 #0472 #0473 #0474 #0475
                        #0476 #0477 #0478
0434  15  -2.89000E+00  -0556 -0549  0439  0531 #0491 #0492 #0493 #0494 #0449
0435  15  -2.89000E+00  -0553 -0533  0550 #0441 #0442 #0445 #0446 #0447 #0448
                        #0449 #0450 #0511 #0512 #0513 #0514 #0515 #0516 #0517
                        #0518 #0519
0436  15  -2.89000E+00  -0552 -0551 -0549 -0548 -0546 -0545 -0544
                        -0543 -0542 -0541 -0519  0518  0547  0550
                        (  0531  0532 ) (  0534 : -0533: -0514:  0515 )
                        #0431 #0432 #0433 #0434 #0435 #0441 #0442 #0443 #0444
                        #0445 #0446 #0447 #0448 #0449 #0450 #0461 #0462 #0463
                        #0464 #0465 #0471 #0472 #0473 #0474 #0475 #0476 #0477
                        #0478 #0491 #0492 #0493 #0494 #0511 #0512 #0513 #0514
                        #0515 #0516 #0517 #0518 #0519
c
c Cell cards modeling the beam ports:
c ===================================
c
c Cell cards modeling beam ports 1 and 5:
c ---------------------------------------
c
c Eleven cells are used to model beam ports 1 and 5:
c  (1) Cell 0441 represents the aluminum tube common to stage 1 of
c      beam ports 1 and 5.
c  (2) Cell 0442 represents the air cavity common to stage 1 of
c      beam ports 1 and 5.
c  (3) Cell 0443 represents the stainless steel tube that forms
c      stage 2 of beam port 1.
c  (4) Cell 0444 represents the air cavity in stage 2 of beam port 1.
c  (5) Cell 0445 represents the stainless steel tube that forms
c      stage 2 of beam port 5.
c  (6) Cell 0446 represents the air cavity in stage 2 of beam port 5.
c  (7) Cell 0447 represents the stainless steel tube that forms
c      stage 3 of beam port 5.
c  (8) Cell 0448 represents the air cavity in stage 3 of beam port 5.
c  (9) Cell 0449 represents the stainless steel tube that forms
c      stage 4 of beam port 5.
```

```
c (10) Cell 0450 represents the air cavity in stage 4 of beam port 5.
c (11) Cell 0451 represents the graphite scattering block in the air cavity
c      common to stage 1 of beam ports 1 and 5. The graphite scattering block
c      serves to scatter neutrons down beam ports 1 and 5 and is said to
c      increase the intensity of the neutron beam at the neutron radiography
c      imaging plane in beam port 5 by a factor of 1.7 (according to a document
c      titled "Beam_Scatterer_Notes.pdf" that was provided by Mr. Michael Krause
c      on 17 November 2015).
c
c     m        d                geom
c     --   -----------  -----------------------
0441  09  -2.70000E+00  -0572 -0562  0561  0571
0442  02  -1.20500E-03  -0572 -0561  0571 #0451
                        #0501 #0505 #0511 #0512
                        #0513 #0514 #0515 #0516
0443  01  -8.00000E+00  -0564 -0544  0563  0572
0444  02  -1.20500E-03  -0563 -0544  0572
0445  01  -8.00000E+00  -0571 -0564  0563  0570
0446  02  -1.20500E-03  -0571 -0563  0570 #0516
                        #0517 #0518 #0519
0447  01  -8.00000E+00  -0570 -0566  0565  0569
0448  02  -1.20500E-03  -0570 -0565  0569
0449  01  -8.00000E+00  -0569 -0568  0550  0567
0450  02  -1.20500E-03  -0569 -0567  0550
0451  03  -1.70000E+00  -0582 -0581  0504
c
c Cell cards modeling beam port 2:
c --------------------------------
c
c Five cells are used to model beam port 2:
c (1) Cell 0461 represents the aluminum tube that forms
c     stage 1 of beam port 2.
c (2) Cell 0462 represents the air cavity in stage 1 of beam port 2.
c (3) Cell 0463 represents the stainless steel tube that forms
c     stage 2 of beam port 2.
c (4) Cell 0464 represents the air cavity in stage 2 of beam port 2.
c (5) Cell 0465 represents the sapphire filter at the end of
c     the first stage of beam port 2.
c
c     m        d                  geom
c     --   -----------  -----------------------------
0461  09  -2.70000E+00  -0615 -0612  0452  0611  0616
0462  02  -1.20500E-03  -0615 -0611  0452  0617 #0502
0463  01  -8.00000E+00  -0616 -0614 -0546  0613
0464  02  -1.20500E-03  -0616 -0613 -0546
0465  16  -3.97000E+00  -0617 -0611  0616
c
c Cell cards modeling beam port 3:
c --------------------------------
c
c Eight cells are used to model beam port 3:
c (1) Cell 0471 represents the aluminum tube that forms
c     stage 1 of beam port 3.
c (2) Cell 0472 represents the air cavity in stage 1 of beam port 3.
c (3) Cell 0473 represents the stainless steel tube that forms
c     stage 2 of beam port 3.
c (4) Cell 0474 represents the air cavity in stage 2 of beam port 3.
c (5) Cell 0475 represents the stainless steel tube that forms
c     stage 3 of beam port 3.
c (6) Cell 0476 represents the air cavity in stage 3 of beam port 3.
c (7) Cell 0477 represents the stainless steel tube that forms
c     stage 4 of beam port 3.
c (8) Cell 0478 represents the air cavity in stage 4 of beam port 3.
c
c     m        d                geom
```

```
c     --   -----------  -----------------------
0471  09  -2.70000E+00  -0632  0631 -0437  0641
0472  02  -1.20500E-03  -0631 -0437  0641 #0503
0473  01  -8.00000E+00  -0641 -0634  0633  0640
0474  02  -1.20500E-03  -0641 -0633  0640
0475  01  -8.00000E+00  -0640 -0636  0635  0639
0476  02  -1.20500E-03  -0640 -0635  0639
0477  01  -8.00000E+00  -0639 -0638  0547  0637
0478  02  -1.20500E-03  -0639 -0637  0547
c
c Cell cards modeling beam port 4:
c --------------------------------
c
c Four cells are used to model beam port 4:
c (1) Cell 0491 represents the aluminum tube that forms
c     stage 1 of beam port 4.
c (2) Cell 0492 represents the air cavity in stage 1 of beam port 4.
c (3) Cell 0493 represents the stainless steel tube that forms
c     stage 2 of beam port 4.
c (4) Cell 0494 represents the air cavity in stage 2 of beam port 4.
c
c     m         d                  geom
c     --   -----------  -----------------------------
0491  09  -2.70000E+00  -0655 -0652  0439  0452  0651
0492  02  -1.20500E-03  -0655 -0651  0439  0452 #0504
0493  01  -8.00000E+00  -0654 -0549  0655  0653
0494  02  -1.20500E-03  -0653 -0549  0655
c
c Cell cards modeling the beam port tally spheres:
c ------------------------------------------------
c
c Five cell cards, cell cards 0501, 0502, 0503, 0504, and 0505, are used to
c model five spheres, one in each of the five beam ports. These spheres are
c not currently being used, but in some other, older MCNP runs they were
c used to evaluate tallies in the beam ports.
c
c     m         d       geom
c     --   -----------  -----
0501  02  -1.20500E-03  -0661  $ The sphere in beam port 1.
0502  02  -1.20500E-03  -0662  $ The sphere in beam port 2.
0503  02  -1.20500E-03  -0663  $ The sphere in beam port 3.
0504  02  -1.20500E-03  -0664  $ The sphere in beam port 4.
0505  02  -1.20500E-03  -0665  $ The sphere in beam port 5.
c
c Cell cards modeling the primary collimator in beam port 5:
c ----------------------------------------------------------
c
c Nine cells are used to model the primary collimator in beam port 5:
c (1) Cell 0511 represents the aluminum insert guide of the primary collimator.
c (2) Cell 0512 represents the boral inlet diaphram of the primary collimator.
c (3) Cell 0513 represents the first part of the iron moderating piece of the
c     primary collimator.
c (4) Cell 0514 represents the second part of the iron moderating piece of
c     the primary collimator.
c (5) Cell 0515 represents the gamma filter of the primary collimator.
c     The gamma filter is a single bismuth crystal.
c (6) Cell 0516 represents the polyethylene moderating piece of the
c     primary collimator.
c (7) Cell 0517 represents the boral primary diaphram of the primary collimator.
c (8) Cell 0518 represents the lead gamma shield of the primary collimator.
c (9) Cell 0519 represents the aluminum fixer disk of the primary collimator.
c
c    m       d               geom
c    --  -----------  ----------------------
0511 09 -2.70000E+00 -0604 -0561  0595  0603
```

```
0512 17 -2.53000E+00 -0603 -0561  0594  0602
0513 18 -7.87400E+00 -0602 -0561  0591  0601
0514 18 -7.87400E+00 -0601 -0561  0595  0600
0515 19 -9.74700E+00 -0601 -0595  0600
0516 20 -9.30000E-01 -0600 -0561  0591  0599
0517 17 -2.53000E+00 -0599 -0561  0593  0598
0518 10 -1.13500E+01 -0598 -0561  0592  0597
0519 09 -2.70000E+00 -0597 -0561  0592  0596

c ==================
c MCNP SURFACE CARDS:
c ==================
c
c Surface cards defining the boundaries of
c the TRIGA fuel elements and control rods:
c ========================================
c
c Surface cards defining the boundaries of the TRIGA fuel elements:
c ----------------------------------------------------------------
c
c The following surface cards define the boundaries of the TRIGA fuel elements.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0001     C/Z              0.00000E+00  4.35356E+00  2.85000E-01
0002     C/Z              0.00000E+00  4.35356E+00  7.87400E-01
0003     C/Z              0.00000E+00  4.35356E+00  1.81610E+00
0004     C/Z              0.00000E+00  4.35356E+00  1.86690E+00
0005     PZ  -3.73474E+01
0006     PZ  -2.84974E+01
0007     PZ  -1.98106E+01
0008     PZ  -1.97319E+01
0009     PZ   1.83681E+01
0010     PZ   2.70549E+01
0011     PZ   2.76366E+01
0012     PZ   3.17387E+01
0013     PZ   3.59297E+01
0014     PZ   3.69297E+01
c
c Surface cards defining the boundaries of the
c fuel-followed regulating and shim control rods:
c -----------------------------------------------
c
c The following surface cards define the boundaries of the fuel-followed
c regulating and shim control rods.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0021     C/Z              0.00000E+00 -8.70712E+00  2.85000E-01
0022     C/Z              0.00000E+00 -8.70712E+00  1.50749E+00
0023     C/Z              0.00000E+00 -8.70712E+00  1.57460E+00
0024     C/Z              0.00000E+00 -8.70712E+00  1.66350E+00
0025     C/Z              0.00000E+00 -8.70712E+00  1.71450E+00
0026     PZ  -7.81519E+01
0027     PZ  -7.68819E+01
0028     PZ  -6.03719E+01
0029     PZ  -5.78319E+01
0030     PZ  -1.90969E+01
0031     PZ  -1.78269E+01
0032     PZ   2.02731E+01
0033     PZ   2.05781E+01
0034     PZ   2.18481E+01
0035     PZ   3.83581E+01
0036     PZ   3.96281E+01
c
```

```
c Surface cards defining the boundaries of
c the air-followed transient control rod:
c ----------------------------------------
c
c The following surface cards define the boundaries of the air-followed
c transient control rod.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0051      C/Z              0.00000E+00  8.70712E+00  1.51130E+00
0052      C/Z              0.00000E+00  8.70712E+00  1.55200E+00
0053      C/Z              0.00000E+00  8.70712E+00  1.58750E+00
0054      PZ  -7.40371E+01
0055      PZ  -7.27621E+01
0056      PZ  -1.71919E+01
0057      PZ   2.09081E+01
0058      PZ   2.47181E+01
c
c Surface cards defining the boundaries of the central thimble
c irradiation facility, the 3-element irradiation facility,
c and the pneumatic transfer system irradiation facility:
c ============================================================
c
c Surface cards defining the boundaries of
c the central thimble irradiation facility:
c ----------------------------------------
c
c The following surface cards define the boundaries of the central thimble
c irradiation facility. The positions of these surfaces were developed from
c information extracted from chapter eight of the Safety Analysis Report for
c the University of Texas at Austin's TRIGA Mark II nuclear research reactor
c (the version dated May 1991).
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0071      CZ               1.18500E+00
0072      CZ               1.69000E+00
0073      CZ               1.90500E+00
0074      PZ              -5.55504E+01
0075      PZ              -5.53474E+01
0076      PZ  -2.50000E+00
0077      PZ   2.50000E+00
0078      PZ   3.15976E+01
c
c Surface cards defining the boundaries
c of the 3-element irradiation facility:
c -------------------------------------
c
c The following surface cards define the boundaries of the 3-element (3L)
c irradiation facility. The positions of these surfaces were developed from
c drawings of the 3L that I received as attachments to an email from Mr. Tracy
c Tipping, who is the health physicist at The University of Texas at Austin's
c Nuclear Engineering Teaching Lab. I received the email on 6 November 2015.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0081      C/Z              8.79798E+00 -1.52375E+01  1.93929E+00
0082      C/Z              8.79798E+00 -1.52375E+01  2.06375E+00
0083      C/Z              8.79798E+00 -1.52375E+01  2.16535E+00
0084      C/Z              8.79798E+00 -1.52375E+01  2.23393E+00
0085      C/Z              8.79798E+00 -1.52375E+01  2.38125E+00
0086      C/Z              8.79798E+00 -1.52375E+01  2.40000E+00
0087      PZ  -3.31723E+01
0088      PZ  -3.06324E+01
0089      PZ  -3.05308E+01
```

```
0090      PZ  -3.02133E+01
0091      PZ   8.75792E+01
0092      PZ   8.94842E+01
0093      PZ   9.16051E+01
0094      PZ   9.47801E+01
c
c The following surface cards detail the PZ & C/Z definitions of the internal
c components of the MODIFIED 3-element (3L) irradiation facility. These
c parameters were developed by Brandon De Luna via the work done in
c constructing the facility. This addition to the facility design via MCNP
c is dated at January 08, 2019.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
c 0700      C/Z             8.79798E+00 -1.52375E+01  2.30759E+00
c 0701      C/Z             8.79798E+00 -1.52375E+01  2.23393E+00
c 0702      C/Z             8.79798E+00 -1.52375E+01  2.13393E+00
c 0703      C/Z             8.79798E+00 -1.52375E+01  2.03393E+00
c 0704      C/Z             8.79798E+00 -1.52375E+01  1.03759E+00
c 0705      C/Z             8.79798E+00 -1.52375E+01  9.63930E-01
c 0706      C/Z             8.79798E+00 -1.52375E+01  9.52500E-01
c 0707      C/Z             8.79798E+00 -1.52375E+01  8.63500E-01
c 0708      C/Z             8.79798E+00 -1.52375E+01  7.94000E-01
c 0709      C/Z             8.79798E+00 -1.52375E+01  6.70000E-01
c 0710      C/Z             8.79798E+00 -1.52375E+01  5.90000E-01
c 0711      C/Z             8.79798E+00 -1.52375E+01  4.50000E-01
c  3L base || Al chunk bottom ----> use surface 0088 as reference here
c 0712      PZ  -3.063240E+01
c  Al chunk bottom || Al lower spacer
c 0713      PZ  -2.255240E+01
c  Al upper spacer || Cd disk bottom
c 0714      PZ  -2.174240E+01
c  Cd disk top || Ag disk bottom
c 0715      PZ  -2.205768E+01
c  Ag disk top || Al disk bottom
c 0716      PZ  -2.215768E+01
c  Ag disk top || Al disk bottom
c 0717      PZ  -2.225768E+01
c  Al disk top/tube lower || B-10/Cd sleeve lower
c 0718      PZ  -2.032268E+01
c  Al tube upper || Ag sleeve lower || pnuematic sleeve lower
c 0719      PZ  -1.778268E+01
c  pneumatic sleeve thickness upper || pneumatic system lower
c 0720      PZ  -1.746518E+01
c  pneumatic system thickness upper || sample height displacement lower
c 0721      PZ  -1.651268E+01
c  sample height displacement upper || quartz sample lower 1
c 0722      PZ  -1.619518E+01
c quartz sample upper 1 || sample lower
c 0723      PZ  -1.524268E+01
c sample upper || quartz sample lower 2
c 0724      PZ  -6.035180E+00
c quartz sample upper 2
c 0725      PZ  -5.400180E+00
c Ag sleeve upper
c 0726      PZ   1.777732E+01
c Al plug annulus lower
c 0727      PZ   3.809732E+01
c Cd sleeve upper
c 0728      PZ   4.063732E+01
c Al plug annulus upper || pnuematic sleeve upper || Al B4C annulus lower
c 0729      PZ   4.317732E+01
c Al B4C annulus thickness upper
c 0730      PZ   4.417732E+01
c
```

```
c THE BELOW ARE MACROBODY DEFINITIONS OF THE 3L INSERT AS MADE BY BRANDON DE LUNA
c
c        AAA x.xxxxxE+xx  y.yyyyyE+yy  zz.zzzzz Hx Hy   Hz   R.RRRR
c        --- -----------  -----------  -------- -- -- ------ ------
0741 RCC 8.79798E+00 -1.52375E+01 39.402320  0 0 52.00278 1.8923000 $ natural B4C pow
0742 RCC 8.79798E+00 -1.52375E+01 39.202320  0 0 52.39938 2.1900898 $ natural B4C pow
0744 RCC 8.79798E+00 -1.52375E+01 39.402320  0 0 52.19938 1.11125 $Al transfer part
0711 RCC 8.79798E+00 -1.52375E+01 -15.87275  0 0 9.00000 0.45 $glass inner air
0712 RCC 8.79798E+00 -1.52375E+01 -16.67275  0 0 10.1600 0.59 $ 4 inch glass
0713 RCC 8.79798E+00 -1.52375E+01 -18.13018  0 0 109.73188 0.67 $ void inside
0714 RCC 8.79798E+00 -1.52375E+01 -18.25418  0 0 109.85588 0.794 $Al pneu inner
0715 RCC 8.79798E+00 -1.52375E+01 -18.25418  0 0 109.85588 0.8635 $air between Al
0716 RCC 8.79798E+00 -1.52375E+01 -18.38268  0 0 109.98438 0.9525000 $ Al pneu
0747 RCC 8.79798E+00 -1.52375E+01 -18.68268  0 0 57.7850 1.0375900 $Pneumatic
0748 RCC 8.79798E+00 -1.52375E+01 -21.22268  0 0 60.3250 2.1708999 $Cd sleeves 0.5 mm
c 0749      RCC 8.79798E+00 -1.52375E+01 -21.22268  0 0 35.5600 2.0900898 $Ag sleeve
0750 RCC 8.79798E+00 -1.52375E+01  13.70232  0 0 22.8600 2.0066000 $Al bp ID#2
0751 RCC 8.79798E+00 -1.52375E+01 -21.85768  0 0 60.9600 2.1208999 $Al bp OD
0752 RCC 8.79798E+00 -1.52375E+01 -21.22268  0 0 34.9250 2.0472400 $Al bp ID#1
0753 RCC 8.79798E+00 -1.52375E+01 -21.95768  0 0 0.10000 2.233930 $Ag disk
0754 RCC 8.79798E+00 -1.52375E+01 -22.05768  0 0 0.10000 2.233930 $Cd disk
0755 RCC 8.79798E+00 -1.52375E+01 -25.55240  0 0 3.49472 2.233930 $Al spacer
0766 RCC 8.79798E+00 -1.52375E+01 -25.55240  0 0 3.00000 2.033930 $air in spacer
0777 RCC 8.79798E+00 -1.52375E+01 -30.63240  0 0 5.08000 2.233930 $Al chunk in 3L
0788 RCC 8.79798E+00 -1.52375E+01 -33.17230  0 0 124.7740 2.30759 $Al-tube #1 OD
0789 RCC 8.79798E+00 -1.52375E+01  10.32510  0 0 114.4523 2.38125 $Al-tube #2 OD
0790 RCC 8.79798E+00 -1.52375E+01 -33.17230  0 0 124.7740 2.23393 $Air #1 OD
c
c Surface cards defining the boundaries of the Swagelok
c PFA plug valve in the 3L irradiation facility:
c -----------------------------------------------------
c
c The following surface cards define the boundaries of the Swagelok PFA plug
c valve in the 3L irradiation facility. The positions of these surfaces are
c calculated in the Excel workbook having the following file name:
c Swagelok_PFA_Plug_Valve_Surface_Position_Calculations.xlsx
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  z.zzzzzE+zz  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------  -----------
c 0101      C/X                        -1.58421E+01 -2.69733E+01  1.97500E-01
c 0102      C/Y              8.79798E+00              -2.69733E+01  6.81500E-01
c 0103      C/Y              8.79798E+00              -2.69733E+01  1.07250E+00
c 0104      C/Z              8.79798E+00 -1.58421E+01              1.97500E-01
c 0105      C/Z              8.79798E+00 -1.58421E+01              3.14000E-01
c 0106      C/Z              8.79798E+00 -1.58421E+01              5.50500E-01
c 0107      C/Z              8.79798E+00 -1.58421E+01              7.83500E-01
c 0108      PY  -1.68001E+01
c 0109      PY  -1.48841E+01
c 0110      PY  -1.34751E+01
c 0111      PZ  -2.98063E+01
c 0112      PZ  -2.88723E+01
c 0113      PZ  -2.69733E+01
c 0114      PZ  -2.50743E+01
c 0115      PZ  -2.42903E+01
c
c Surface cards defining the boundaries of the
c pneumatic transfer system irradiation facility:
c -----------------------------------------------
c
c The following surface cards define the boundaries of the pneumatic transfer
c system irradiation facility.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
c 0121      C/Z             -1.13106E+01  1.95910E+01  8.69950E-01
```

```
c 0122     C/Z           -1.13106E+01  1.95910E+01  1.11125E+00
c 0123     C/Z           -1.13106E+01  1.95910E+01  1.16205E+00
c 0124     C/Z           -1.13106E+01  1.95910E+01  1.53543E+00
c 0125     C/Z           -1.13106E+01  1.95910E+01  1.74625E+00
c 0126     PZ  -3.58275E+00
c 0127     PZ  -3.37193E+00
c 0128     PZ  -2.99855E+00
c 0129     PZ  -2.94775E+00
c 0130     PZ  -2.07645E+00
c 0131     PZ   5.00000E+01
c
c Surface cards defining the boundaries of the rotary specimen
c rack outer housing and the rotary specimen rack sample tubes:
c ============================================================
c
c Surface cards defining the boundaries of
c the rotary specimen rack outer housing:
c ----------------------------------------
c
c The following surface cards define the boundaries of the rotary specimen rack
c outer housing.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0141     CZ             2.75376E+01
0142     CZ             2.82727E+01
0143     CZ             3.02394E+01
0144     CZ             3.08745E+01
0145     CZ             3.60388E+01
0146     CZ             3.66737E+01
0147     PZ   8.90270E+00
0148     PZ   9.53770E+00
0149     PZ   3.40352E+01
0150     PZ   3.63538E+01
0151     PZ   4.36690E+01
0152     PZ   4.44627E+01
c
c Surface cards defining the boundaries of
c the rotary specimen rack sample tubes:
c ----------------------------------------
c
c The following surface cards define the boundaries of the rotary specimen rack
c sample tubes.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0161     C/Z            3.34563E+01  0.00000E+00  1.74625E+00
0162     C/Z            3.34563E+01  0.00000E+00  1.67259E+00
0163     PZ   1.08077E+01
0164     PZ   1.09550E+01
0165     PZ   4.01193E+01
c
c Surface cards defining the boundaries of four rotary specimen rack flux wires:
c ------------------------------------------------------------------------------
c
c The following surface cards define the boundaries of four rotary specimen rack
c flux wires. Note that the four flux wires are assumed to be located in four
c rotary specimen rack sample tubes spaced at equal intervals around the rotary
c specimen rack. It should also be noted that the flux wires are assumed to have
c diameters of 0.038 cm (0.015 in) in accordance with a Shieldwerx cobalt flux
c wire material analysis sheet provided by Shieldwerx (Don Hanna)
c on 16 July 2015. Furthermore, the flux wires are assumed to have lengths of
c 1 cm, and they are assumed to be sitting 0.5 cm above the bottom surface of
c the rotary specimen rack sample tubes.
c
```

```
c      nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c      ---- ---  -----------  -----------  -----------  -----------
0171       C/Z              3.34563E+01  0.00000E+00  1.90000E-02
0172       C/Z              0.00000E+00  3.34563E+01  1.90000E-02
0173       C/Z             -3.34563E+01  0.00000E+00  1.90000E-02
0174       C/Z              0.00000E+00 -3.34563E+01  1.90000E-02
0175       PZ   1.14550E+01
0176       PZ   1.24550E+01
c
c Surfaces cards defining the boundaries of the bottom and top grid plates:
c ===========================================================================
c
c Surface cards defining the outer boundaries of the bottom grid plate:
c ---------------------------------------------------------------------
c
c The following surface cards define the outer boundaries of the bottom
c grid plate.
c
c    nnnn AAA  A.AAAAAE+AA  B.BBBBBE+BB  C.CCCCCE+CC  D.DDDDDE+DD
c    ---- ---  -----------  -----------  -----------  -----------
0181      PX                               2.47980E+01
0182      P    1.72325E+00  1.00000E+00  0.00000E+00  5.22533E+01
0183      P    5.77110E-01  1.00000E+00  0.00000E+00  2.86332E+01
0184      PY                               2.61214E+01
0185      P   -5.77110E-01  1.00000E+00  0.00000E+00  2.86332E+01
0186      P   -1.72325E+00  1.00000E+00  0.00000E+00  5.22533E+01
0187      PX                              -2.47980E+01
0188      P   -1.72325E+00 -1.00000E+00  0.00000E+00  5.22533E+01
0189      P   -5.77110E-01 -1.00000E+00  0.00000E+00  2.86332E+01
0190      PY                              -2.61214E+01
0191      P    5.77110E-01 -1.00000E+00  0.00000E+00  2.86332E+01
0192      P    1.72325E+00 -1.00000E+00  0.00000E+00  5.22533E+01
0193      PZ                              -3.63474E+01
0194      PZ                              -3.31724E+01
c
c Surface cards defining the outer boundaries of the top grid plate:
c -----------------------------------------------------------------
c
c The following surface cards define the outer boundaries of the top grid plate.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0200      CZ              2.76225E+01
0201      PZ   3.08102E+01
0202      PZ   3.23850E+01
c
c Surface cards defining the boundaries of the
c bottom and top grid plate fuel element cut-outs:
c ------------------------------------------------
c
c The following surface cards define the boundaries of the bottom and top grid
c plate fuel element cut-outs. There is one cut-out in the bottom grid plate and
c one cut-out in the top grid plate for each of the 121 reactor core locations,
c and thus there are 121 cylindrical surfaces in the following list.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------
0211      CZ                            1.91135E+00 $ The A01 cut-out.
0212      C/Z  0.00000E+00  4.35356E+00  1.91135E+00 $ The B01 cut-out.
0213      C/Z  3.76936E+00  2.17678E+00  1.91135E+00 $ The B02 cut-out.
0214      C/Z  3.76936E+00 -2.17678E+00  1.91135E+00 $ The B03 cut-out.
0215      C/Z  0.00000E+00 -4.35356E+00  1.91135E+00 $ The B04 cut-out.
0216      C/Z -3.76936E+00 -2.17678E+00  1.91135E+00 $ The B05 cut-out.
0217      C/Z -3.76936E+00  2.17678E+00  1.91135E+00 $ The B06 cut-out.
0218      C/Z  0.00000E+00  8.70712E+00  1.91135E+00 $ The C01 cut-out.
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0219    C/Z  3.76936E+00  6.53034E+00  1.91135E+00 $ The C02 cut-out.
0220    C/Z  7.54126E+00  4.35356E+00  1.91135E+00 $ The C03 cut-out.
0221    C/Z  7.54126E+00  0.00000E+00  1.91135E+00 $ The C04 cut-out.
0222    C/Z  7.54126E+00 -4.35356E+00  1.91135E+00 $ The C05 cut-out.
0223    C/Z  3.76936E+00 -6.53034E+00  1.91135E+00 $ The C06 cut-out.
0224    C/Z  0.00000E+00 -8.70712E+00  1.91135E+00 $ The C07 cut-out.
0225    C/Z -3.76936E+00 -6.53034E+00  1.91135E+00 $ The C08 cut-out.
0226    C/Z -7.54126E+00 -4.35356E+00  1.91135E+00 $ The C09 cut-out.
0227    C/Z -7.54126E+00  0.00000E+00  1.91135E+00 $ The C10 cut-out.
0228    C/Z -7.54126E+00  4.35356E+00  1.91135E+00 $ The C11 cut-out.
0229    C/Z -3.76936E+00  6.53034E+00  1.91135E+00 $ The C12 cut-out.
0230    C/Z  0.00000E+00  1.30607E+01  1.91135E+00 $ The D01 cut-out.
0231    C/Z  3.76936E+00  1.08839E+01  1.91135E+00 $ The D02 cut-out.
0232    C/Z  7.54126E+00  8.70712E+00  1.91135E+00 $ The D03 cut-out.
0233    C/Z  1.13106E+01  6.53034E+00  1.91135E+00 $ The D04 cut-out.
0234    C/Z  1.13106E+01  2.17678E+00  1.91135E+00 $ The D05 cut-out.
0235    C/Z  1.13106E+01 -2.17678E+00  1.91135E+00 $ The D06 cut-out.
0236    C/Z  1.13016E+01 -6.53034E+00  1.91135E+00 $ The D07 cut-out.
0237    C/Z  7.54126E+00 -8.70712E+00  1.91135E+00 $ The D08 cut-out.
0238    C/Z  3.76936E+00 -1.08839E+01  1.91135E+00 $ The D09 cut-out.
0239    C/Z  0.00000E+00 -1.30607E+01  1.91135E+00 $ The D10 cut-out.
0240    C/Z -3.76936E+00 -1.08839E+01  1.91135E+00 $ The D11 cut-out.
0241    C/Z -7.54126E+00 -8.70712E+00  1.91135E+00 $ The D12 cut-out.
0242    C/Z -1.13016E+01 -6.53034E+00  1.91135E+00 $ The D13 cut-out.
0243    C/Z -1.13106E+01 -2.17678E+00  1.91135E+00 $ The D14 cut-out.
0244    C/Z -1.13106E+01  2.17678E+00  1.91135E+00 $ The D15 cut-out.
0245    C/Z -1.13106E+01  6.53034E+00  1.91135E+00 $ The D16 cut-out.
0246    C/Z -7.54126E+00  8.70712E+00  1.91135E+00 $ The D17 cut-out.
0247    C/Z -3.76936E+00  1.08839E+01  1.91135E+00 $ The D18 cut-out.
0248    C/Z  0.00000E+00  1.74142E+01  1.91135E+00 $ The E01 cut-out.
0249    C/Z  3.76936E+00  1.52375E+01  1.91135E+00 $ The E02 cut-out.
0250    C/Z  7.54126E+00  1.30607E+01  1.91135E+00 $ The E03 cut-out.
0251    C/Z  1.13106E+01  1.08839E+01  1.91135E+00 $ The E04 cut-out.
0252    C/Z  1.50825E+01  8.70712E+00  1.91135E+00 $ The E05 cut-out.
0253    C/Z  1.50825E+01  4.35356E+00  1.91135E+00 $ The E06 cut-out.
0254    C/Z  1.50825E+01  0.00000E+00  1.91135E+00 $ The E07 cut-out.
0255    C/Z  1.50825E+01 -4.35356E+00  1.91135E+00 $ The E08 cut-out.
0256    C/Z  1.50825E+01 -8.70712E+00  1.91135E+00 $ The E09 cut-out.
0257    C/Z  1.13106E+01 -1.08839E+01  1.91135E+00 $ The E10 cut-out.
0258    C/Z  7.54126E+00 -1.30607E+01  1.91135E+00 $ The E11 cut-out.
0259    C/Z  3.76936E+00 -1.52375E+01  1.91135E+00 $ The E12 cut-out.
0260    C/Z  0.00000E+00 -1.74142E+01  1.91135E+00 $ The E13 cut-out.
0261    C/Z -3.76936E+00 -1.52375E+01  1.91135E+00 $ The E14 cut-out.
0262    C/Z -7.54126E+00 -1.30607E+01  1.91135E+00 $ The E15 cut-out.
0263    C/Z -1.13106E+01 -1.08839E+01  1.91135E+00 $ The E16 cut-out.
0264    C/Z -1.50825E+01 -8.70712E+00  1.91135E+00 $ The E17 cut-out.
0265    C/Z -1.50825E+01 -4.35356E+00  1.91135E+00 $ The E18 cut-out.
0266    C/Z -1.50825E+01  0.00000E+00  1.91135E+00 $ The E19 cut-out.
0267    C/Z -1.50825E+01  4.35356E+00  1.91135E+00 $ The E20 cut-out.
0268    C/Z -1.50825E+01  8.70712E+00  1.91135E+00 $ The E21 cut-out.
0269    C/Z -1.13106E+01  1.08839E+01  1.91135E+00 $ The E22 cut-out.
0270    C/Z -7.54126E+00  1.30607E+01  1.91135E+00 $ The E23 cut-out.
0271    C/Z -3.76936E+00  1.52375E+01  1.91135E+00 $ The E24 cut-out.
0272    C/Z  0.00000E+00  2.17678E+01  1.91135E+00 $ The F01 cut-out.
0273    C/Z  3.76936E+00  1.95910E+01  1.91135E+00 $ The F02 cut-out.
0274    C/Z  7.54126E+00  1.74142E+01  1.91135E+00 $ The F03 cut-out.
0275    C/Z  1.13106E+01  1.52375E+01  1.91135E+00 $ The F04 cut-out.
0276    C/Z  1.50825E+01  1.30607E+01  1.91135E+00 $ The F05 cut-out.
0277    C/Z  1.88519E+01  1.08839E+01  1.91135E+00 $ The F06 cut-out.
0278    C/Z  1.88519E+01  6.53034E+00  1.91135E+00 $ The F07 cut-out.
0279    C/Z  1.88519E+01  2.17678E+00  1.91135E+00 $ The F08 cut-out.
0280    C/Z  1.88519E+01 -2.17678E+00  1.91135E+00 $ The F09 cut-out.
0281    C/Z  1.88519E+01 -6.53034E+00  1.91135E+00 $ The F10 cut-out.
0282    C/Z  1.88519E+01 -1.08839E+01  1.91135E+00 $ The F11 cut-out.
0283    C/Z  1.50825E+01 -1.30607E+01  1.91135E+00 $ The F12 cut-out.
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0284     C/Z  1.13106E+01 -1.52375E+01  1.91135E+00 $ The F13 cut-out.
0285     C/Z  7.54126E+00 -1.74142E+01  1.91135E+00 $ The F14 cut-out.
0286     C/Z  3.76936E+00 -1.95910E+01  1.91135E+00 $ The F15 cut-out.
0287     C/Z  0.00000E+00 -2.17678E+01  1.91135E+00 $ The F16 cut-out.
0288     C/Z -3.76936E+00 -1.95910E+01  1.91135E+00 $ The F17 cut-out.
0289     C/Z -7.54126E+00 -1.74142E+01  1.91135E+00 $ The F18 cut-out.
0290     C/Z -1.13106E+01 -1.52375E+01  1.91135E+00 $ The F19 cut-out.
0291     C/Z -1.50825E+01 -1.30607E+01  1.91135E+00 $ The F20 cut-out.
0292     C/Z -1.88519E+01 -1.08839E+01  1.91135E+00 $ The F21 cut-out.
0293     C/Z -1.88519E+01 -6.53034E+00  1.91135E+00 $ The F22 cut-out.
0294     C/Z -1.88519E+01 -2.17678E+00  1.91135E+00 $ The F23 cut-out.
0295     C/Z -1.88519E+01  2.17678E+00  1.91135E+00 $ The F24 cut-out.
0296     C/Z -1.88519E+01  6.53034E+00  1.91135E+00 $ The F25 cut-out.
0297     C/Z -1.88519E+01  1.08839E+01  1.91135E+00 $ The F26 cut-out.
0298     C/Z -1.50825E+01  1.30607E+01  1.91135E+00 $ The F27 cut-out.
0299     C/Z -1.13106E+01  1.52375E+01  1.91135E+00 $ The F28 cut-out.
0300     C/Z -7.54126E+00  1.74142E+01  1.91135E+00 $ The F29 cut-out.
0301     C/Z -3.76936E+00  1.95910E+01  1.91135E+00 $ The F30 cut-out.
0302     C/Z  3.76936E+00  2.39446E+01  1.91135E+00 $ The G02 cut-out.
0303     C/Z  7.54126E+00  2.17678E+01  1.91135E+00 $ The G03 cut-out.
0304     C/Z  1.13106E+01  1.95910E+01  1.91135E+00 $ The G04 cut-out.
0305     C/Z  1.50825E+01  1.74142E+01  1.91135E+00 $ The G05 cut-out.
0306     C/Z  1.88519E+01  1.52375E+01  1.91135E+00 $ The G06 cut-out.
0307     C/Z  2.26212E+01  8.70712E+00  1.91135E+00 $ The G08 cut-out.
0308     C/Z  2.26212E+01  4.35356E+00  1.91135E+00 $ The G09 cut-out.
0309     C/Z  2.26212E+01  0.00000E+00  1.91135E+00 $ The G10 cut-out.
0310     C/Z  2.26212E+01 -4.35356E+00  1.91135E+00 $ The G11 cut-out.
0311     C/Z  2.26212E+01 -8.70712E+00  1.91135E+00 $ The G12 cut-out.
0312     C/Z  1.88519E+01 -1.52375E+01  1.91135E+00 $ The G14 cut-out.
0313     C/Z  1.50825E+01 -1.74142E+01  1.91135E+00 $ The G15 cut-out.
0314     C/Z  1.13106E+01 -1.95910E+01  1.91135E+00 $ The G16 cut-out.
0315     C/Z  7.54126E+00 -2.17678E+01  1.91135E+00 $ The G17 cut-out.
0316     C/Z  3.76936E+00 -2.39446E+01  1.91135E+00 $ The G18 cut-out.
0317     C/Z -3.76936E+00 -2.39446E+01  1.91135E+00 $ The G20 cut-out.
0318     C/Z -7.54126E+00 -2.17678E+01  1.91135E+00 $ The G21 cut-out.
0319     C/Z -1.13106E+01 -1.95910E+01  1.91135E+00 $ The G22 cut-out.
0320     C/Z -1.50825E+01 -1.74142E+01  1.91135E+00 $ The G23 cut-out.
0321     C/Z -1.88519E+01 -1.52375E+01  1.91135E+00 $ The G24 cut-out.
0322     C/Z -2.26212E+01 -8.70712E+00  1.91135E+00 $ The G26 cut-out.
0323     C/Z -2.26212E+01 -4.35356E+00  1.91135E+00 $ The G27 cut-out.
0324     C/Z -2.26212E+01  0.00000E+00  1.91135E+00 $ The G28 cut-out.
0325     C/Z -2.26212E+01  4.35356E+00  1.91135E+00 $ The G29 cut-out.
0326     C/Z -2.26212E+01  8.70712E+00  1.91135E+00 $ The G30 cut-out.
0327     C/Z -1.88519E+01  1.52375E+01  1.91135E+00 $ The G32 cut-out.
0328     C/Z -1.50825E+01  1.74142E+01  1.91135E+00 $ The G33 cut-out.
0329     C/Z -1.13106E+01  1.95910E+01  1.91135E+00 $ The G34 cut-out.
0330     C/Z -7.54126E+00  2.17678E+01  1.91135E+00 $ The G35 cut-out.
0331     C/Z -3.76936E+00  2.39446E+01  1.91135E+00 $ The G36 cut-out.
c
c Surfaces cards defining the boundaries of the
c other cut-outs unique to the bottom grid plate:
c -----------------------------------------------
c
c The following surface cards define the boundaries of the other cut-outs that
c are unique to the bottom grid plate.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------
0351     C/Z  2.19964E+01  1.27000E+01  5.15940E-01
0352     C/Z  1.11252E+00  2.54000E+01  3.96870E-01
0353     C/Z  0.00000E+00  2.54000E+01  5.15940E-01
0354     C/Z -8.79856E+00  1.08839E+01  5.55620E-01
0355     C/Z -2.19964E+01  1.27000E+01  5.15940E-01
0356     C/Z -2.19964E+01 -1.27000E+01  5.15940E-01
0357     C/Z  0.00000E+00 -2.54000E+01  5.15940E-01
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0358     C/Z  1.11252E+00 -2.54000E+01  3.96870E-01
0359     C/Z  8.79856E+00 -1.52375E+01  5.55620E-01
0360     C/Z  2.19964E+01 -1.27000E+01  5.15940E-01
c
c Surface cards defining the boundaries of the other cut-outs
c that are common to both the bottom and top grid plates:
c ----------------------------------------------------------
c
c The following surface cards define the boundaries of the other cut-outs that
c are common to both the bottom and top grid plates.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------
0371     C/Z -2.38785E+01 -2.17678E+00  2.57810E-01
0372     C/Z -2.00929E+01 -2.17678E+00  2.57810E-01
0373     C/Z -1.63398E+01 -2.17678E+00  2.57810E-01
0374     C/Z -1.38252E+01 -2.17678E+00  2.57810E-01
0375     C/Z -8.79856E+00 -2.17678E+00  2.57810E-01
0376     C/Z -6.28396E+00 -2.17678E+00  2.57810E-01
0377     C/Z -1.25730E+00 -2.17678E+00  2.57810E-01
0378     C/Z  1.25730E+00 -2.17678E+00  2.57810E-01
0379     C/Z  6.28396E+00 -2.17678E+00  2.57810E-01
0380     C/Z  8.79856E+00 -2.17678E+00  2.57810E-01
0381     C/Z  1.38252E+01 -2.17678E+00  2.57810E-01
0382     C/Z  1.63398E+01 -2.17678E+00  2.57810E-01
0383     C/Z  2.00929E+01 -2.17678E+00  2.57810E-01
0384     C/Z  2.38785E+01 -2.17678E+00  2.57810E-01
0385     C/Z  1.25730E+00 -2.39446E+01  2.57810E-01
0386     C/Z  1.25730E+00 -1.95910E+01  2.57810E-01
0387     C/Z  1.25730E+00 -1.52375E+01  2.57810E-01
0388     C/Z  1.25730E+00 -1.08839E+01  2.57810E-01
0389     C/Z  1.25730E+00 -6.53034E+00  2.57810E-01
0390     C/Z  1.25730E+00  2.17678E+00  2.57810E-01
0391     C/Z  1.25730E+00  6.53034E+00  2.57810E-01
0392     C/Z  1.25730E+00  1.08839E+01  2.57810E-01
0393     C/Z  1.25730E+00  1.52375E+01  2.57810E-01
0394     C/Z  1.25730E+00  1.95910E+01  2.57810E-01
0395     C/Z  1.25730E+00  2.39446E+01  2.57810E-01
c
c Surface cards defining the boundaries of the
c other cut-outs unique to the top grid plate:
c --------------------------------------------
c
c The following surface cards define the boundaries of the other cut-outs that
c are unique to the top grid plate.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------
0411     C/Z  2.66700E+01 -1.11252E+00  3.17500E-01
0412     C/Z  2.66700E+01  0.00000E+00  5.15940E-01
0413     C/Z  1.33350E+01  2.30962E+01  5.15940E-01
0414     C/Z -1.33350E+01  2.30962E+01  5.15940E-01
0415     C/Z -2.17170E+01  1.25476E+01  7.93750E-01
0416     C/Z -2.66700E+01  0.00000E+00  5.15940E-01
0417     C/Z -2.66700E+01 -1.11252E+00  3.17500E-01
0418     C/Z -1.33350E+01 -2.30962E+01  5.15940E-01
0419     C/Z  1.33350E+01 -2.30962E+01  5.15940E-01
0420     C/Z  2.17170E+01 -1.25476E+01  7.93750E-01
c
c Surface cards defining the boundaries of the
c reflector inner, outer, lower, and upper shrouds:
c ==================================================
c
c Surface cards defining the boundaries of the reflector inner shroud:
c --------------------------------------------------------------------
```

```
c
c The following surface cards define the outer and upper boundaries of the
c reflector inner shroud. The lower and inner boundaries of the reflector inner
c shroud are formed by the surface cards used to define the outer boundaries of
c the bottom grid plate.
c
c    nnnn AAA  A.AAAAAE+AA  B.BBBBBE+BB  C.CCCCCE+CC  D.DDDDDE+DD
c    ---- ---  -----------  -----------  -----------  -----------
0431      PX                             2.54330E+01
0432      P    1.72325E+00  1.00000E+00  0.00000E+00  5.35234E+01
0433      P    5.77110E-01  1.00000E+00  0.00000E+00  2.93636E+01
0434      PY                             2.67564E+01
0435      P   -5.77110E-01  1.00000E+00  0.00000E+00  2.93636E+01
0436      P   -1.72325E+00  1.00000E+00  0.00000E+00  5.35234E+01
0437      PX                            -2.54330E+01
0438      P   -1.72325E+00 -1.00000E+00  0.00000E+00  5.35234E+01
0439      P   -5.77110E-01 -1.00000E+00  0.00000E+00  2.93636E+01
0440      PY                            -2.67564E+01
0441      P    5.77110E-01 -1.00000E+00  0.00000E+00  2.93636E+01
0442      P    1.72325E+00 -1.00000E+00  0.00000E+00  5.35234E+01
0443      PZ                             2.89052E+01
c
c Surface cards defining the boundaries of the reflector outer shroud:
c --------------------------------------------------------------------
c
c The following surface cards define the boundaries of the reflector
c outer shroud.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0451      CZ                5.34988E+01
0452      CZ                5.47688E+01
0453      PZ  -3.22199E+01
0454      PZ   2.87401E+01
c
c Surface cards defining the boundaries of the reflector lower shroud:
c --------------------------------------------------------------------
c
c The following surface cards define the boundaries of the reflector
c lower shroud.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0461      PZ  -2.92100E+01
0462      PZ  -2.79400E+01
0463      CZ                5.22288E+01
c
c Surface cards defining the boundaries of the reflector upper shroud:
c --------------------------------------------------------------------
c
c The following surface cards define the boundaries of the reflector
c upper shroud.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0471      CZ                2.94481E+01
0472      CZ                3.00831E+01
0473      CZ                3.68300E+01
0474      CZ                3.74650E+01
0475      PZ   6.99770E+00
0476      PZ   7.63270E+00
0477      PZ   2.63652E+01
0478      PZ   3.39852E+01
0479      PZ   2.82702E+01
0480      PZ   2.95402E+01
```

```
c
c Surface cards defining the boundaries of the reflector
c shroud around the beam port 3 reflector penetration:
c ------------------------------------------------------
c
c The following surface cards define the boundaries of the reflector shroud
c around the beam port 3 penetration.
c
c    nnnn AAA  y.yyyyyE+yy  z.zzzzzE+zz  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------
0491      C/X  0.00000E+00 -6.98500E+00  9.52500E+00
0492      C/X  0.00000E+00 -6.98500E+00  1.01600E+01
c
c Surface cards defining the boundaries of the
c reflector cut-out adjacent to beam ports 1 and 5:
c -------------------------------------------------
c
c The following surface cards define the boundaries of the reflector cut-out
c adjacent to beam ports 1 and 5.
c
c    nnnn AAA  D.DDDDDE+DD
c    ---- ---  -----------
0501      PX   3.52552E+01
0502      PZ  -1.53850E+01
0503      PZ   1.41500E+00
0504      PY  -9.52500E+00
0505      PY   9.52500E+00
c
c Surface cards defining the outer surfaces of the reactor pool water
c volumes, the aluminum reactor pool liner, and the biological shield:
c ======================================================================
c
c Surface cards defining the outer boundaries of the reactor pool water volumes:
c ------------------------------------------------------------------------------
c
c The following surface cards are used to define the outer boundaries of three
c reactor pool water volumes. The three water volumes collectively constitute
c the larger reactor pool water volume: surfaces 0511, 0518, and 0519 define
c the outer boundaries of one reactor pool water volume; surfaces 0512, 0513,
c 0518, and 0519 define the outer boundaries of a second reactor pool water
c volume; and surfaces 0512, 0513, 0514, 0515, 0516, 0517, 0518, and 0519
c define the outer boundaries of a third reactor pool water volume.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
c
0511      CZ                                          2.70000E+01
0512      CZ                                          9.90600E+01
0513      C/Z               9.90600E+01  0.00000E+00  9.90600E+01
0514      PX   0.00000E+00
0515      PX   9.90600E+01
0516      PY  -9.90600E+01
0517      PY   9.90600E+01
0518      PZ  -9.71850E+01
0519      PZ   9.50000E+01
c
c Surface cards defining the outer boundaries
c of the aluminum reactor pool liner:
c -------------------------------------------
c
c The following surface cards are used to define the outer boundaries of the
c aluminum reactor pool liner that separates the reactor pool water from the
c biological shield.
c
c    nnnn AAA  D.DDDDDE+DD  x.xxxxxE+xx  y.yyyyyE+yy  R.RRRRRE+RR
```

```
c    ---- ---  -----------  -----------  -----------  -----------
0531      CZ                                    1.00330E+02
0532      C/Z             9.90600E+01  0.00000E+00  1.00330E+02
0533      PY  -1.00330E+02
0534      PY   1.00330E+02
c
c Surface cards defining the outer boundaries of the biological shield:
c -------------------------------------------------------------------
c
c The following surface cards are used to define the outer boundaries of the
c biological shield.
c
c    nnnn AAA  A.AAAAAAE+AA  B.BBBBBE+BB  C.CCCCCE+CC  D.DDDDDE+DD
c    ---- ---  -----------  -----------  -----------  -----------
0541      PX                                    3.88620E+02
0542      P    1.73212E+00  1.00000E+00  0.00000E+00  7.60924E+02
0543      P    5.77551E-01  1.00000E+00  0.00000E+00  4.22392E+02
0544      PY                                    3.42900E+02
0545      P   -5.77844E-01  1.00000E+00  0.00000E+00  3.96014E+02
0546      P   -1.74715E+00  1.00000E+00  0.00000E+00  6.89491E+02
0547      PX                                   -3.42900E+02
0548      P   -1.74715E+00 -1.00000E+00  0.00000E+00  6.89491E+02
0549      P   -5.77844E-01 -1.00000E+00  0.00000E+00  3.96014E+02
0550      PY                                   -3.42900E+02
0551      P    5.77551E-01 -1.00000E+00  0.00000E+00  4.22392E+02
0552      P    1.73212E+00 -1.00000E+00  0.00000E+00  7.60924E+02
c
c Surface cards defining the outer boundaries of five
c cylindrical volumes surrounding each of the five beam ports:
c -----------------------------------------------------------
c
c The following surface cards are used to define the outer boundaries of five
c cylindrical volumes surrounding each of the five beam ports.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  z.zzzzzE+zz  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0553      C/Y  3.52552E+01              -6.98500E+00  3.50000E+01 $ BP 1 and 5.
0554 0554 CX                                   3.50000E+01 $ BP 2.
0555      C/X             0.00000E+00 -6.98500E+00  3.50000E+01 $ BP 3.
0556 0556 CX                                   3.50000E+01 $ BP 4.
c
c Surface cards defining the boundaries of beam ports 1, 2, 3, 4, and 5:
c ========================================================================
c
c Surface cards defining the boundaries of beam ports 1 and 5:
c -----------------------------------------------------------
c
c The following surface cards define the boundaries of beam ports 1 and 5.
c
c    nnnn AAA -D.DDDDDE+DD -x.xxxxxE+xx -z.zzzzzE+zz -R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0561      C/Y             3.52552E+01 -6.98500E+00  7.77875E+00
0562      C/Y             3.52552E+01 -6.98500E+00  8.41375E+00
0563      C/Y             3.52552E+01 -6.98500E+00  1.03188E+01
0564      C/Y             3.52552E+01 -6.98500E+00  1.09538E+01
0565      C/Y             3.52552E+01 -6.98500E+00  1.55575E+01
0566      C/Y             3.52552E+01 -6.98500E+00  1.61925E+01
0567      C/Y             3.52552E+01 -6.98500E+00  1.96850E+01
0568      C/Y             3.52552E+01 -6.98500E+00  2.03200E+01
0569      PY  -2.51460E+02
0570      PY  -1.67640E+02
0571      PY  -1.23190E+02
0572      PY   1.80000E+02
c
c Surface cards defining the boundaries of the
```

```
c graphite scattering block in beam ports 1 and 5:
c -----------------------------------------------
c
c The following surface cards define the boundaries of the graphite scattering
c block in beam ports 1 and 5. The positions of these surfaces were developed
c from information extracted from the doctoral dissertation of Young Gyun Jo
c titled "Development of a Thermal Neutron Imaging Facility for Real Time
c Neutron Radiography and Computed Tomography."
c
c    nnnn AAA -D.DDDDDE+DD -x.xxxxxE+xx -z.zzzzzE+zz -R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0581      PY  -2.54000E+00
0582      C/Y              3.52552E+01 -6.98500E+00  6.35000E+00
c
c Surface cards defining the boundaries of
c the primary collimator in beam port 5:
c ----------------------------------------
c
c The following surface cards define the boundaries of the primary collimator
c in beam port 5. The positions of these surfaces were developed from
c information extracted from the doctoral dissertation of Young Gyun Jo
c titled "Development of a Thermal Neutron Imaging Facility for Real
c Time Neutron Radiography and Computed Tomography."
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  z.zzzzzE+zz  t.tttttE+tt  +/-1
c    ---- ---  -----------  -----------  -----------  -----------  ----
0591      K/Y  3.52552E+01 -1.86820E+02 -6.98500E+00  1.55000E-03  1
0592      K/Y  3.52552E+01 -1.10620E+02 -6.98500E+00  1.55000E-03 -1
c
c    nnnn AAA  D.DDDDDE+DD -x.xxxxxE+xx -z.zzzzzE+zz -R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0593      C/Y              3.52552E+01 -6.98500E+00  1.00000E+00
0594      C/Y              3.52552E+01 -6.98500E+00  2.63000E+00
0595      C/Y              3.52552E+01 -6.98500E+00  3.24000E+00
0596      PY  -1.56340E+02
0597      PY  -1.53800E+02
0598      PY  -1.48820E+02
0599      PY  -1.48080E+02
0600      PY  -1.20140E+02
0601      PY  -1.17220E+02
0602      PY  -1.10620E+02
0603      PY  -1.09340E+02
0604      PY  -1.01700E+02
c
c Surface cards defining the boundaries of beam port 2:
c -----------------------------------------------------
c
c The following surface cards define the boundaries of beam port 2.
c
c    nnnn AAA  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------
0611 0611 CX               7.77875E+00
0612 0612 CX               8.41375E+00
0613 0613 CX               1.03188E+01
0614 0614 CX               1.09538E+01
0615 0615 PX   0.00000E+00
0616 0616 PX   0.00000E+00
0617 0617 PX   0.00000E+00
c
c Surface cards defining the boundaries of beam port 3:
c -----------------------------------------------------
c
c The following surface cards define the boundaries of beam port 3.
c
c    nnnn AAA  D.DDDDDE+DD  y.yyyyyE+yy  z.zzzzzE+zz  R.RRRRRE+RR
```

```
c    ---- ---  -----------  -----------  -----------  -----------
0631      C/X             0.00000E+00 -6.98500E+00  7.70255E+00
0632      C/X             0.00000E+00 -6.98500E+00  8.41375E+00
0633      C/X             0.00000E+00 -6.98500E+00  1.03188E+01
0634      C/X             0.00000E+00 -6.98500E+00  1.09538E+01
0635      C/X             0.00000E+00 -6.98500E+00  1.55575E+01
0636      C/X             0.00000E+00 -6.98500E+00  1.61925E+01
0637      C/X             0.00000E+00 -6.98500E+00  1.96850E+01
0638      C/X             0.00000E+00 -6.98500E+00  2.03200E+01
0639      PX  -2.51460E+02
0640      PX  -1.67640E+02
0641      PX  -1.23190E+02
c
c Surface cards defining the boundaries of beam port 4:
c -----------------------------------------------------
c
c The following surface cards define the boundaries of beam port 4.
c
c    nnnn AAA  A.AAAAAE+AA  B.BBBBBE+BB  C.CCCCCE+CC  D.DDDDDE+DD  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------  -----------
0651 0651 CX                                          7.77875E+00
0652 0652 CX                                          8.41375E+00
0653 0653 CX                                          1.03188E+01
0654 0654 CX                                          1.09538E+01
0655 0655 P   -5.77110E-01 -1.00000E+00  0.00000E+00  2.86332E+01
c
c Surface cards defining the boundaries of five spheres that
c may be used to support evaluating beam port flux tallies:
c ---------------------------------------------------------
c
c The following surface cards define the boundaries of five spheres, one in
c each of the five beam ports. These spheres are not currently being used,
c but in some other, older MCNP runs they were used to evaluate tallies
c in each of the beam ports.
c
c    nnnn AAA  x.xxxxxE+xx  y.yyyyyE+yy  z.zzzzzE+zz  R.RRRRRE+RR
c    ---- ---  -----------  -----------  -----------  -----------
0661      S    3.52552E+01  5.40000E+01 -6.98500E+00  2.50000E+00
0662      S   -3.00000E+01  5.60000E+01 -6.98500E+00  2.50000E+00
0663      S   -6.50000E+01  0.00000E+00 -6.98500E+00  2.50000E+00
0664      S   -3.30000E+01 -5.60000E+01 -6.98500E+00  2.50000E+00
0665      S    3.52552E+01 -5.40000E+01 -6.98500E+00  2.50000E+00

c ================
c MCNP DATA CARDS:
c ================
c
c TR: Coordinate transformations:
c ==============================
c
c Note that unless noted otherwise all of the control rod and fuel element
c coordinate transformations are relative to the fuel element in reactor core
c location B01. Also note that because the coordinate transformations are
c relative to the fuel element in reactor core location B01, the fuel element
c in reactor core location B01 does not require any coordinate transformations.
c
c B-ring fuel element coordinate transformations:
c -----------------------------------------------
c
c          o1           o2           o3
c       -----------  -----------  -----------
TR0082  3.76936E+00 -2.17678E+00  0.00000E+00 $ Fuel element in location B02.
TR0083  3.76936E+00 -6.53034E+00  0.00000E+00 $ Fuel element in location B03.
TR0084  0.00000E+00 -8.70712E+00  0.00000E+00 $ Fuel element in location B04.
TR0085 -3.76936E+00 -6.53034E+00  0.00000E+00 $ Fuel element in location B05.
```

```
TR0086 -3.76936E+00 -2.17678E+00  0.00000E+00 $ Fuel element in location B06.
c
c C-ring fuel element and control rod coordinate transformations:
c ---------------------------------------------------------------
c
c          o1          o2          o3
c      -----------  -----------  -----------
TR0087  0.00000E+00  0.00000E+00  2.80000E+01 $ Transient rod in location C01.
c 2.26220E+01
TR0088  3.76936E+00  2.17678E+00  0.00000E+00 $ Fuel element in location C02.
TR0089  7.54126E+00  0.00000E+00  0.00000E+00 $ Fuel element in location C03.
TR0090  7.54126E+00 -4.35356E+00  0.00000E+00 $ Fuel element in location C04.
TR0091  7.54126E+00 -8.70712E+00  0.00000E+00 $ Fuel element in location C05.
TR0092  3.76936E+00 -1.08839E+01  0.00000E+00 $ Fuel element in location C06.
TR0093  0.00000E+00  0.00000E+00  2.80000E+01 $ Regulating rod in location C07.
c 2.26220E+01
TR0094 -3.76936E+00 -1.08839E+01  0.00000E+00 $ Fuel element in location C08.
TR0095 -7.54126E+00 -8.70712E+00  0.00000E+00 $ Fuel element in location C09.
TR0096 -7.54126E+00 -4.35356E+00  0.00000E+00 $ Fuel element in location C10.
TR0097 -7.54126E+00  0.00000E+00  0.00000E+00 $ Fuel element in location C11.
TR0098 -3.76936E+00  2.17678E+00  0.00000E+00 $ Fuel element in location C12.
c
c D-ring fuel element and control rod coordinate transformations:
c ---------------------------------------------------------------
c
c Note that the coordinate transformations associated with shim rod 1 and
c shim rod 2, coordinate transformations TR325 and TR333, respectively,
c are relative to the regulating rod in reactor core location C07.
c
c          o1          o2          o3
c      -----------  -----------  -----------
TR0099  0.00000E+00  8.70714E+00  0.00000E+00 $ Fuel element in location D01.
TR0100  3.76936E+00  6.53034E+00  0.00000E+00 $ Fuel element in location D02.
TR0101  7.54126E+00  4.35356E+00  0.00000E+00 $ Fuel element in location D03.
TR0102  1.13106E+01  2.17678E+00  0.00000E+00 $ Fuel element in location D04.
TR0103  1.13106E+01 -2.17678E+00  0.00000E+00 $ Fuel element in location D05.
TR0104  1.13106E+01  6.53034E+00  2.80000E+01 $ Shim rod 1 in location D06.
c 2.26220E+01
TR0105  1.13016E+01 -1.08839E+01  0.00000E+00 $ Fuel element in location D07.
TR0106  7.54126E+00 -1.30607E+01  0.00000E+00 $ Fuel element in location D08.
TR0107  3.76936E+00 -1.52375E+01  0.00000E+00 $ Fuel element in location D09.
TR0108  0.00000E+00 -1.74143E+01  0.00000E+00 $ Fuel element in location D10.
TR0109 -3.76936E+00 -1.52375E+01  0.00000E+00 $ Fuel element in location D11.
TR0110 -7.54126E+00 -1.30607E+01  0.00000E+00 $ Fuel element in location D12.
TR0111 -1.13016E+01 -1.08839E+01  0.00000E+00 $ Fuel element in location D13.
TR0112 -1.13106E+01  6.53034E+00  2.80000E+01 $ Shim rod 2 in location D14.
c 2.26220E+01
TR0113 -1.13106E+01 -2.17678E+00  0.00000E+00 $ Fuel element in location D15.
TR0114 -1.13106E+01  2.17678E+00  0.00000E+00 $ Fuel element in location D16.
TR0115 -7.54126E+00  4.35356E+00  0.00000E+00 $ Fuel element in location D17.
TR0116 -3.76936E+00  6.53034E+00  0.00000E+00 $ Fuel element in location D18.
c
c E-ring fuel element coordinate transformations:
c ----------------------------------------------
c
c Note that the coordinate transformation associated with the fuel element
c in reactor core location E11, coordinate transformation TR348, should be
c commented out if the 3L is in the reactor core.
c
c          o1          o2          o3
c      -----------  -----------  -----------
TR0117  0.00000E+00  1.30606E+01  0.00000E+00 $ Fuel element in location E01.
TR0118  3.76936E+00  1.08839E+01  0.00000E+00 $ Fuel element in location E02.
TR0119  7.54126E+00  8.70714E+00  0.00000E+00 $ Fuel element in location E03.
TR0120  1.13106E+01  6.53034E+00  0.00000E+00 $ Fuel element in location E04.
```

```
TR0121  1.50825E+01  4.35356E+00  0.00000E+00 $ Fuel element in location E05.
TR0122  1.50825E+01  0.00000E+00  0.00000E+00 $ Fuel element in location E06.
TR0123  1.50825E+01 -4.35356E+00  0.00000E+00 $ Fuel element in location E07.
TR0124  1.50825E+01 -8.70712E+00  0.00000E+00 $ Fuel element in location E08.
TR0125  1.50825E+01 -1.30607E+01  0.00000E+00 $ Fuel element in location E09.
TR0126  1.13106E+01 -1.52375E+01  0.00000E+00 $ Fuel element in location E10.
c TR0127  7.54126E+00 -1.74143E+01  0.00000E+00 $ Fuel element in location E11.
TR0128  3.76936E+00 -1.95911E+01  0.00000E+00 $ Fuel element in location E12.
TR0129  0.00000E+00 -2.17678E+01  0.00000E+00 $ Fuel element in location E13.
TR0130 -3.76936E+00 -1.95911E+01  0.00000E+00 $ Fuel element in location E14.
TR0131 -7.54126E+00 -1.74143E+01  0.00000E+00 $ Fuel element in location E15.
TR0132 -1.13106E+01 -1.52375E+01  0.00000E+00 $ Fuel element in location E16.
TR0133 -1.50825E+01 -1.30607E+01  0.00000E+00 $ Fuel element in location E17.
TR0134 -1.50825E+01 -8.70712E+00  0.00000E+00 $ Fuel element in location E18.
TR0135 -1.50825E+01 -4.35356E+00  0.00000E+00 $ Fuel element in location E19.
TR0136 -1.50825E+01  0.00000E+00  0.00000E+00 $ Fuel element in location E20.
TR0137 -1.50825E+01  4.35356E+00  0.00000E+00 $ Fuel element in location E21.
TR0138 -1.13106E+01  6.53034E+00  0.00000E+00 $ Fuel element in location E22.
TR0139 -7.54126E+00  8.70714E+00  0.00000E+00 $ Fuel element in location E23.
TR0140 -3.76936E+00  1.08839E+01  0.00000E+00 $ Fuel element in location E24.
c
c F-ring fuel element coordinate transformations:
c -----------------------------------------------
c
c Note that the coordinate transformations associated with the fuel elements
c in reactor core locations F13 and F14, coordinate transformations TR374
c and TR375, respectively, should be commented out if the 3L is in the
c reactor core.
c
c           o1          o2          o3
c       ----------- ----------- -----------
TR0141  0.00000E+00  1.74142E+01  0.00000E+00 $ Fuel element in location F01.
TR0142  3.76936E+00  1.52374E+01  0.00000E+00 $ Fuel element in location F02.
TR0143  7.54126E+00  1.30606E+01  0.00000E+00 $ Fuel element in location F03.
TR0144  1.13106E+01  1.08839E+01  0.00000E+00 $ Fuel element in location F04.
TR0145  1.50825E+01  8.70714E+00  0.00000E+00 $ Fuel element in location F05.
TR0146  1.88519E+01  6.53034E+00  0.00000E+00 $ Fuel element in location F06.
TR0147  1.88519E+01  2.17678E+00  0.00000E+00 $ Fuel element in location F07.
TR0148  1.88519E+01 -2.17678E+00  0.00000E+00 $ Fuel element in location F08.
TR0149  1.88519E+01 -6.53034E+00  0.00000E+00 $ Fuel element in location F09.
TR0150  1.88519E+01 -1.08839E+01  0.00000E+00 $ Fuel element in location F10.
TR0151  1.88519E+01 -1.52375E+01  0.00000E+00 $ Fuel element in location F11.
TR0152  1.50825E+01 -1.74142E+01  0.00000E+00 $ Fuel element in location F12.
c TR0153  1.13106E+01 -1.95910E+01  0.00000E+00 $ Fuel element in location F13.
c TR0154  7.54126E+00 -2.17678E+01  0.00000E+00 $ Fuel element in location F14.
TR0155  3.76936E+00 -2.39446E+01  0.00000E+00 $ Fuel element in location F15.
TR0156  0.00000E+00 -2.61214E+01  0.00000E+00 $ Fuel element in location F16.
TR0157 -3.76936E+00 -2.39446E+01  0.00000E+00 $ Fuel element in location F17.
TR0158 -7.54126E+00 -2.17678E+01  0.00000E+00 $ Fuel element in location F18.
TR0159 -1.13106E+01 -1.95911E+01  0.00000E+00 $ Fuel element in location F19.
TR0160 -1.50825E+01 -1.74143E+01  0.00000E+00 $ Fuel element in location F20.
TR0161 -1.88519E+01 -1.52375E+01  0.00000E+00 $ Fuel element in location F21.
TR0162 -1.88519E+01 -1.08839E+01  0.00000E+00 $ Fuel element in location F22.
TR0163 -1.88519E+01 -6.53034E+00  0.00000E+00 $ Fuel element in location F23.
TR0164 -1.88519E+01 -2.17678E+00  0.00000E+00 $ Fuel element in location F24.
TR0165 -1.88519E+01  2.17678E+00  0.00000E+00 $ Fuel element in location F25.
TR0166 -1.88519E+01  6.53034E+00  0.00000E+00 $ Fuel element in location F26.
TR0167 -1.50825E+01  8.70714E+00  0.00000E+00 $ Fuel element in location F27.
TR0168 -1.13106E+01  1.08839E+01  0.00000E+00 $ Fuel element in location F28.
TR0169 -7.54126E+00  1.30606E+01  0.00000E+00 $ Fuel element in location F29.
TR0170 -3.76936E+00  1.52374E+01  0.00000E+00 $ Fuel element in location F30.
c
c G-ring fuel element coordinate transformations:
c -----------------------------------------------
c
```

```
c Note that there are no coordinate transformations associated with the G01,
c G07, G13, G19, G25, G31, G32, or G34 reactor core locations because there
c are not fuel elements in any of these reactor core locations. Reactor core
c locations G01, G07, G13, G19, G25, and G31 are the locations that would
c be at the outer corners of the G-ring if they were actual reactor core
c locations (they're not real), and reactor core locations G32 and G34
c sometimes contain the AmBe startup source and the pneumatic transfer
c system irradiation facility, respectively, depending on the reactor
c core configuration.
c
c          o1          o2          o3
c      -----------  -----------  -----------
TR0171  3.76936E+00  1.95910E+01  0.00000E+00 $ Fuel element in location G02.
TR0172  7.54126E+00  1.74142E+01  0.00000E+00 $ Fuel element in location G03.
TR0173  1.13106E+01  1.52374E+01  0.00000E+00 $ Fuel element in location G04.
TR0174  1.50825E+01  1.30606E+01  0.00000E+00 $ Fuel element in location G05.
TR0175  1.88519E+01  1.08839E+01  0.00000E+00 $ Fuel element in location G06.
TR0176  2.26212E+01  4.35356E+00  0.00000E+00 $ Fuel element in location G08.
TR0177  2.26212E+01  0.00000E+00  0.00000E+00 $ Fuel element in location G09.
TR0178  2.26212E+01 -4.35356E+00  0.00000E+00 $ Fuel element in location G10.
TR0179  2.26212E+01 -8.70712E+00  0.00000E+00 $ Fuel element in location G11.
TR0180  2.26212E+01 -1.30606E+01  0.00000E+00 $ Fuel element in location G12.
TR0181  1.88519E+01 -1.95911E+01  0.00000E+00 $ Fuel element in location G14.
TR0182  1.50825E+01 -2.17678E+01  0.00000E+00 $ Fuel element in location G15.
TR0183  1.13106E+01 -2.39446E+01  0.00000E+00 $ Fuel element in location G16.
TR0184  7.54126E+00 -2.61214E+01  0.00000E+00 $ Fuel element in location G17.
TR0185  3.76936E+00 -2.82982E+01  0.00000E+00 $ Fuel element in location G18.
TR0186 -3.76936E+00 -2.82982E+01  0.00000E+00 $ Fuel element in location G20.
TR0187 -7.54126E+00 -2.61214E+01  0.00000E+00 $ Fuel element in location G21.
TR0188 -1.13106E+01 -2.39446E+01  0.00000E+00 $ Fuel element in location G22.
TR0189 -1.50825E+01 -2.17678E+01  0.00000E+00 $ Fuel element in location G23.
TR0190 -1.88519E+01 -1.95911E+01  0.00000E+00 $ Fuel element in location G24.
TR0191 -2.26212E+01 -1.30607E+01  0.00000E+00 $ Fuel element in location G26.
TR0192 -2.26212E+01 -8.70712E+00  0.00000E+00 $ Fuel element in location G27.
TR0193 -2.26212E+01 -4.35356E+00  0.00000E+00 $ Fuel element in location G28.
TR0194 -2.26212E+01  0.00000E+00  0.00000E+00 $ Fuel element in location G29.
TR0195 -2.26212E+01  4.35356E+00  0.00000E+00 $ Fuel element in location G30.
TR0196 -1.50825E+01  1.30606E+01  0.00000E+00 $ Fuel element in location G33.
TR0197 -7.54126E+00  1.74142E+01  0.00000E+00 $ Fuel element in location G35.
TR0198 -3.76936E+00  1.95910E+01  0.00000E+00 $ Fuel element in location G36.
c
c Coordinate transformations supporting beam port 2 alignment:
c -----------------------------------------------------------
c
c Note that the values assigned to each of the keywords of the coordinate
c transformation cards that follow are provided to a precision of seven digits
c as opposed to six digits (most values in this MCNP input deck are provided
c to a precision of six digits) in order to prevent the generation of
c non-orthogonality warning messages.
c
*TR0554  0.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
       -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
        6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
        9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0611  0.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
       -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
        6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
        9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0612  0.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
       -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
        6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
        9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
```

```
*TR0613  0.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
      -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
       6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0614  0.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
      -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
       6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0615  8.000000E+00  3.959470E+01 -6.985000E+00 $ o1, o2, and o3 keywords.
      -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
       6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0616 -1.305640E+02  1.195947E+02 -6.985000E+00 $ o1, o2, and o3 keywords.
      -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
       6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0617 -1.245640E+02  1.195947E+02 -6.985000E+00 $ o1, o2, and o3 keywords.
      -3.000000E+01 -1.200000E+02  9.000000E+01 $ xx', yx', and zx' keywords.
       6.000000E+01 -3.000000E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
c Coordinate transformations supporting beam port 4 alignment:
c ------------------------------------------------------------
c
c Note that the values assigned to each of the keywords of the coordinate
c transformation cards that follow are provided to a precision of seven digits
c as opposed to six digits (most values in this MCNP input deck are provided
c to a precision of six digits) in order to prevent the generation of
c non-orthogonality warning messages.
c
*TR0556  0.000000E+00  0.000000E+00 -6.985000E+00 $ o1, o2, and o3 keywords.
       5.986650E+01 -3.013350E+01  9.000000E+01 $ xx', yx', and zx' keywords.
       1.498665E+02  5.986650E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0651  0.000000E+00  0.000000E+00 -6.985000E+00 $ o1, o2, and o3 keywords.
       5.986650E+01 -3.013350E+01  9.000000E+01 $ xx', yx', and zx' keywords.
       1.498665E+02  5.986650E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0652  0.000000E+00  0.000000E+00 -6.985000E+00 $ o1, o2, and o3 keywords.
       5.986650E+01 -3.013350E+01  9.000000E+01 $ xx', yx', and zx' keywords.
       1.498665E+02  5.986650E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0653  0.000000E+00  0.000000E+00 -6.985000E+00 $ o1, o2, and o3 keywords.
       5.986650E+01 -3.013350E+01  9.000000E+01 $ xx', yx', and zx' keywords.
       1.498665E+02  5.986650E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR0654  0.000000E+00  0.000000E+00 -6.985000E+00 $ o1, o2, and o3 keywords.
       5.986650E+01 -3.013350E+01  9.000000E+01 $ xx', yx', and zx' keywords.
       1.498665E+02  5.986650E+01  9.000000E+01 $ xy', yy', and zy' keywords.
       9.000000E+01  9.000000E+01  0.000000E+00 $ xz', yz', and zz' keywords.
c
*TR655 -8.000000E+01 -1.385640E+02 -6.985000E+00 $ o1, o2, and o3 keywords.
c
c Material data cards:
c ===================
c
c Stainless steel alloy 304 material data cards:
```

```
c ---------------------------------------------
c
c The following material data cards provide material data for stainless steel
c alloy 304. The material data reproduced below was extracted from the Pacific
c Northwest National Laboratory Compendium of Material Composition Data for
c Radiation Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M01  006000.70c  1.83000E-03 $ Natural C at T = 293.6 K.
     014000.60c  9.78100E-03 $ Natural Si at T = 293.6 K.
     015031.70c  4.08000E-04 $ P-31 at T = 293.6 K.
     016000.62c  2.57000E-04 $ Natural S at T = 293.6 K.
     024000.50c  2.00762E-01 $ Natural Cr at T = 293.6 K.
     025055.70c  1.00010E-02 $ Mn-55 at T = 293.6 K.
     026000.50c  6.90375E-01 $ Natural Fe at T = 293.6 K.
     028000.50c  8.65870E-02 $ Natural Ni at T = 293.6 K.
c
c Air material data cards:
c ------------------------
c
c The following material data cards provide material data for air, or, more
c specifically, for dry air near sea level. The material data reproduced below
c was extracted from the Pacific Northwest National Laboratory Compendium of
c Material Composition Data for Radiation Transport
c Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M02  006000.70c  1.50000E-04 $ Natural C at T = 293.6 K.
     007014.70c  7.84431E-01 $ N-14 at T = 293.6 K.
     008016.70c  2.10748E-01 $ O-16 at T = 293.6 K.
     018000.59c  4.67100E-03 $ Natural Ar at T = 293.6 K.
c
c Graphite material data cards:
c -----------------------------
c
c The following material data cards provide material data for graphite.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M03  005010.70c  2.00000E-07 $ B-10 at T = 293.6 K.
     005011.70c  8.00000E-07 $ B-11 at T = 293.6 K.
     006000.70c  9.99999E-01 $ Natural C at T = 293.6 K.
c
MT03 grph.20t $ Thermal neutron scattering data for
c              natural carbon in graphite at T = 293.6 K.
c
c Zirconium material data cards:
c ------------------------------
c
c The following material data cards provide material data for natural zirconium.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M04  040000.66c  1.00000E+00 $ Natural Zr at T = 293.6 K.
c
c Uranium zirconium hydride material data cards:
c ---------------------------------------------
```

```
c
c The following material data cards provide material data for uranium
c ziconium hydride. The uranium, zirconium, and hydrogen isotope
c fractions on the material data cards were calculated in the
c Excel workbook having the following file name:
c UZrH_Material_Data_Calculations.xlsx
c
c      ZAID      Fraction
c    ----------  -----------
M05  001001.71c  6.06927E-01 $ H-1 at T = 600 K.
     040090.71c  1.95165E-01 $ Zr-90 at T = 600 K.
     040091.71c  4.25608E-02 $ Zr-91 at T = 600 K.
     040092.71c  6.50550E-02 $ Zr-92 at T = 600 K.
     040094.71c  6.59274E-02 $ Zr-94 at T = 600 K.
     040096.71c  1.06212E-02 $ Zr-96 at T = 600 K.
     092234.71c  6.00280E-07 $ U-234 at T = 600 K.
     092235.71c  2.70751E-03 $ U-235 at T = 600 K.
     092238.71c  1.10356E-02 $ U-238 at T = 600 K.
c
MT05 zr/h.23t $ Thermal neutron scattering data for natural ~~~~~~~made change
c              zirconium in zirconium hydride at T = 600 K.
     h/zr.23t $ Thermal neutron scattering data for H-1 in
c              zirconium hydride at T = 600 K.
c
c Molybdenum material data cards:
c -------------------------------
c
c The following material data cards provide material data for natural
c molybdenum. The material data reproduced below was extracted from the Pacific
c Northwest National Laboratory Compendium of Material Composition Data for
c Radiation Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M06  042000.66c  1.00000E+00 $ Natural Mo at T = 293.6 K.
c
c Water material data cards:
c --------------------------
c
c The following material data cards provide material data for liquid water.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M07  001001.70c  6.66657E-01 $ H-1 at T = 293.6 K.
     008016.70c  3.33343E-01 $ O-16 at T = 293.6 K.
c
MT07 lwtr.20t $ Thermal neutron scattering data for H-1 in water at T = 293.6 K.
c
c Boron carbide material data cards:
c ----------------------------------
c
c The following material data cards provide material data for boron carbide.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1). Note that Pacific Northwest National
c Laboratory reports a single atom fraction for what is assumed to be natural
c boron, but the boron atom fractions below are broken down into B-10 and B-11
c atom fractions where the B-10 to B-11 ratio is the ratio associated with
c natural boron reported by the National Institue of Standards and Technology.
c
c      ZAID      Fraction
c    ----------  -----------
```

```
M08  005010.70c  1.59996E-01 $ B-10 at T = 293.6 K.
     005011.70c  6.39985E-01 $ B-11 at T = 293.6 K.
     006000.70c  2.00019E-01 $ Natural C at T = 293.6 K.
c
c Aluminum alloy 6061 material data cards:
c ---------------------------------------
c
c The following material data cards provide material data for aluminum
c alloy 6061. The material data reproduced below was extracted from the Pacific
c Northwest National Laboratory Compendium of Material Composition Data for
c Radiation Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M09  012000.66c  1.11620E-02 $ Natural Mg at T = 293.6 K.
     013027.70c  9.77325E-01 $ Al-27 at T = 293.6 K.
     014000.60c  5.79600E-03 $ Natural Si at T = 293.6 K.
     022000.62c  4.99000E-04 $ Natural Ti at T = 293.6 K.
     024000.50c  1.01700E-03 $ Natural Cr at T = 293.6 K.
     025055.70c  4.35000E-04 $ Mn-55 at T = 293.6 K.
     026000.50c  1.98700E-03 $ Natural Fe at T = 293.6 K.
     029000.50c  1.17400E-03 $ Natural Cu at T = 293.6 K.
     030000.70c  6.06000E-04 $ Natural Zn at T = 293.6 K.
c
MT09 al27.22t $ Thermal neutron scattering data for Al-27 at T = 293.6 K.
c
c Lead material data cards:
c -------------------------
c
c The following material data cards provide material data for natural lead.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M10  082000.50c  1.00000E+00 $ Natural Pb at T = 293.6 K.
c
c Perfluoroalkoxy alkane (PFA) material data cards:
c -------------------------------------------------
c
c The following material data cards provide material data for perfluoroalkoxy
c alkane (PFA). The carbon, oxygen, and fluorine isotope fractions on the
c material data cards were calculated in the Excel workbook having the
c following file name: PFA_Constituent_Atom_Fraction_Calc.xlsx
c
c      ZAID      Fraction
c    ----------  -----------
M11  006000.70c  3.12500E-01 $ Natural C at T = 293.6 K.
     008016.70c  6.25000E-02 $ O-16 at T = 293.6 K.
     009019.70c  6.25000E-01 $ F-19 at T = 293.6 K.
c
c Xenon gas material data cards:
c ------------------------------
c
c The following material data cards provide material data for each of the pure
c xenon gases of interest. Only one of the xenon material data cards should be
c active at a time; the other xenon material data cards should be commented out.
c
c      ZAID      Fraction
c    ----------  -----------
M12  054130.00c  1.00000E+00 $ Xe-130 at 293.6 K.
c M12  054131.00c  1.00000E+00 $ Xe-131 at 293.6 K.
c M12  054131.01c  1.00000E+00 $ Xe-131m at 293.6 K.
c M12  054132.00c  1.00000E+00 $ Xe-132 at 293.6 K.
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```
c M12  054133.00c  1.00000E+00 $ Xe-133 at 293.6 K.
c M12  054133.01c  1.00000E+00 $ Xe-133m at 293.6 K.
c M12  054134.00c  1.00000E+00 $ Xe-134 at 293.6 K.
c M12  054135.00c  1.00000E+00 $  Xe-135 at 293.6 K.
c M12  054135.01c  1.00000E+00 $ Xe-135m at 293.6 K.
c
c Cadmium material data cards:
c ----------------------------
c
c The following material data cards provide material data for natural cadmium.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M13  048000.51c  1.00000E+00 $ Natural Cd at T = 293.6 K.
c
c Cobalt material data cards:
c ---------------------------
c
c The following material data cards provide material data for the cobalt
c flux wires. The cobalt flux wires are assumed to be pure, natural cobalt,
c which has a natural isotopic composition of 100 % Co-59. Note that the
c cobalt flux wires manufactured by Shieldwerx are 99.95 % pure cobalt
c according to the Shieldwerx material analysis report provided by
c Don Hanna on 16 July 2015.
c
c      ZAID      Fraction
c    ----------  -----------
M14  027059.70c  1.00000E+00 $ Co-59 at T = 293.6 K.
c
c Concrete material data cards:
c -----------------------------
c
c The following material data cards provide material data for the high density
c concrete that forms the first level of the biological shield. The Safety
c Analysis Report for the University of Texas at Austin's TRIGA Mark II nuclear
c research reactor (the version dated May 1991) states that the concrete is
c steel rebar reinforced high density concrete with a magnetite aggregate, but
c detailed composition information could not be located. The material data
c reproduced below was extracted from the Pacific Northwest National Laboratory
c Compendium of Material Composition Data for Radiation Transport
c Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M15  001001.70c  8.60690E-02 $ H-1 at T = 293.6 K.
     008016.70c  3.14488E-01 $ O-16 at T = 293.6 K.
     012000.66c  5.51600E-03 $ Natural Mg at T = 293.6 K.
     013027.70c  1.40300E-02 $ Al-27 at T = 293.6 K.
     014000.60c  2.04990E-02 $ Natural Si at T = 293.6 K.
     020000.66c  5.07690E-02 $ Natural Ca at T = 293.6 K.
     022000.62c  1.21920E-02 $ Natural Ti at T = 293.6 K.
     023000.70c  4.64000E-04 $ Natural V at T = 293.6 K.
     026000.50c  4.95972E-01 $ Natural Fe at T = 293.6 K.
c
c Aluminum oxide material data cards:
c -----------------------------------
c
c The following material data cards provide material data for aluminum oxide.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
```

```
c      ZAID      Fraction
c    ----------  -----------
M16  008016.70c  6.00000E-01 $ O-16 at T = 293.6 K.
     013027.70c  4.00000E-01 $ Al-27 at T = 293.6 K.
c
c Boral material data cards:
c --------------------------
c
c The following material data cards provide material data for Boral (65 % Al
c and 35 % boron carbide). The material data reproduced below was extracted
c from the Pacific Northwest National Laboratory Compendium of Material
c Composition Data for Radiation Transport Modeling (PNNL-15870 Rev. 1).
c Note that Pacific Northwest National Laboratory reports a single atom
c fraction for what is assumed to be natural boron, but the boron atom
c fractions below are broken down into B-10 and B-11 atom fractions where
c the B-10 to B-11 ratio is the ratio associated with natural boron reported
c by the National Institue of Standards and Technology.
c
c      ZAID      Fraction
c    ----------  -----------
M17  005010.70c  9.04469E-02 $ B-10 at T = 293.6 K.
     005011.70c  3.64060E-01 $ B-11 at T = 293.6 K.
     006000.70c  1.13475E-01 $ Natural C at T = 293.6 K.
     013027.70c  4.32018E-01 $ Al-27 at T = 293.6 K.
c
c Iron material data cards:
c -------------------------
c
c The following material data cards provide material data for natural iron.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M18  026000.50c  1.00000E+00 $ Natural Fe at T = 293.6 K.
c
c Bismuth material data cards:
c ----------------------------
c
c The following material data cards provide material data for bismuth.
c The material data reproduced below was extracted from the Pacific Northwest
c National Laboratory Compendium of Material Composition Data for Radiation
c Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M19  083209.70c  1.00000E+00 $ Natural Bi at T = 293.6 K.
c
c Polyethylene material data cards:
c ---------------------------------
c
c The following material data cards provide material data for non-borated
c polyethylene. The material data reproduced below was extracted from the
c Pacific Northwest National Laboratory Compendium of Material Composition
c Data for Radiation Transport Modeling (PNNL-15870 Rev. 1).
c
c      ZAID      Fraction
c    ----------  -----------
M20  001001.70c  6.66662E-01 $ H-1 at T = 293.6 K.
     006000.70c  3.33338E-01 $ Natural C at T = 293.6 K.
c
M21  13027.70c -1 $aluminum metal
M22  5010.70c  -0.96 5011.70c -0.04 $enriched boron 10 powder
c M23  7014.70c  -0.58314   5010.70c  -0.083372 5011.70c -0.333488 $BN natural
```

```
M24  48106.70c -0.011777  48108.70c -0.008543  48110.70c -0.122116  & $Cd
    48111.70c -0.126284  48112.70c -0.24021  48113.70c -0.122734  &
    48114.70c -0.29111  48116.70c -0.077225
c M25     6000.70c -0.240183 9019.70c -0.759818 $TEFLON
M25     8016.70c -0.5325653  14028.70c -0.431082 $rough QUARTZ glass
       14029.70c -0.0218993  14030.70c -0.0144531 $rough QUARTZ glass
M26     5011.70c -0.8 5010.70c -0.2 $natural boron powder
M27     47107.70c -0.51839 47109.70c -0.48161 $silver foil
M30     94238.70c -0.0005 94239.70c -0.935 94240.70c -0.06 $weapons grade Pu
       94241.70c -0.004  94242.70c -0.0005
M31     1001.70c -1.0000
c
c XS: Cross-section evaluation files:
c ==================================
c
c The following XS cards direct MCNP to cross-section evaluations specific to
c each of the pure xenon gases of interest. Only the XS card associated with the
c active xenon material data card should be active; the other XS cards should
c be commented out. Note that the ACE formatted files associated with the
c cross-section evaluations are assumed to be located in the same directory
c as this MCNP input deck.
c
XS1 54130.00c 128.787600 054130.00c 0 1 1 459604 0 0 2.530E-08 ptable
c XS1 54131.00c 129.780500 054131.00c 0 1 1 881582 0 0 2.530E-08 ptable
c XS1 54131.01c 129.780500 054131.01c 0 1 1 350728 0 0 2.530E-08 ptable
c XS1 54132.00c 130.771000 054132.00c 0 1 1 500694 0 0 2.530E-08 ptable
c XS1 54133.00c 131.764200 054133.00c 0 1 1 489824 0 0 2.530E-08 ptable
c XS1 54133.01c 131.764200 054133.01c 0 1 1 357702 0 0 2.530E-08 ptable
c XS1 54134.00c 132.755100 054134.00c 0 1 1 423933 0 0 2.530E-08 ptable
c XS1 54135.00c 133.748300 054135.00c 0 1 1 545678 0 0 2.530E-08 ptable
c XS1 54135.01c 133.748300 054135.01c 0 1 1 337320 0 0 2.530E-08 ptable
c
c MODE: Specify which particle and photon types should be transported:
c ======================================================================
c
c Include only an "N" designator on the MODE card to
c specify that MCNP should transport only neutrons.
c
MODE N
c
c KCODE: Use the criticality source to determine keff:
c ====================================================
c
c Set the "nsrck" keyword equal to 100,000 to instruct MCNP to run 100,000
c source histories per KCODE cycle. Set the "rkk" keyword equal to 1.0 to
c specify that the initial guess at keff should be 1.0. Set the "ikz" keyword
c equal to 100 and the "kct" keyword equal to 200 to instruct MCNP to run
c a total of 200 KCODE cycles and ignore the first 100 KCODE cycles for
c purposes of calculating keff.
c
KCODE 500000 1.0 100 300
c CHANGING PARTICLE COUNT FROM PREVIOUS "bnSub" WW generations
c FROM 100000 TO 1000000 TO 5000000 TO 100000 and 200 to 225
c note there were 6 WW generations done before this.
c note WW generations generated will not be used for k calcs
c KSRC: Specify the initial source point locations:
c ================================================
c
c Note that the initial source point locations specified on the KSRC card
c that follows are only utilized by the first KCODE cycle of an initiate
c run. Subsequent initiate run KCODE cycles and all continue run KCODE
c cycles utilize the fission sites generated by previous KCODE cycles.
c
c Specify the initial source point locations associated with the B-ring
c fuel elements. These source point locations are at the centers of
```

```
c the B-ring fuel elements.
c
c        x           y          z
c    -----------  -----------  -----------
KSRC  0.00000E+00  4.35356E+00  0.00000E+00 $ Fuel Element B01.
      3.76936E+00  2.17678E+00  0.00000E+00 $ Fuel Element B02.
      3.76936E+00 -2.17678E+00  0.00000E+00 $ Fuel Element B03.
      0.00000E+00 -4.35356E+00  0.00000E+00 $ Fuel Element B04.
     -3.76936E+00 -2.17678E+00  0.00000E+00 $ Fuel Element B05.
     -3.76936E+00  2.17678E+00  0.00000E+00 $ Fuel Element B06.
c
c Specify the initial source point locations associated with the C-ring
c fuel elements. These initial source point locations are at the centers
c of the C-ring fuel elements. Note that there are no initial source point
c locations associated with the C01 or C07 reactor core locations because
c there are not fuel elements in either of these reactor core locations.
c
c        x           y          z
c    -----------  -----------  -----------
      3.76936E+00 -6.53034E+00  0.00000E+00 $ Fuel Element C02.
      7.54126E+00  4.35356E+00  0.00000E+00 $ Fuel Element C03.
      7.54126E+00  0.00000E+00  0.00000E+00 $ Fuel Element C04.
      7.54126E+00 -4.35356E+00  0.00000E+00 $ Fuel Element C05.
     -3.76936E+00 -6.53034E+00  0.00000E+00 $ Fuel Element C06.
     -3.76936E+00  6.53034E+00  0.00000E+00 $ Fuel Element C08.
     -7.54126E+00 -4.35356E+00  0.00000E+00 $ Fuel Element C09.
     -7.54126E+00  0.00000E+00  0.00000E+00 $ Fuel Element C10.
     -7.54126E+00  4.35356E+00  0.00000E+00 $ Fuel Element C11.
      3.76936E+00  6.53034E+00  0.00000E+00 $ Fuel Element C12.
c
c Specify the initial source point locations associated with the D-ring
c fuel elements. These initial source point locations are at the centers
c of the D-ring fuel elements. Note that there are no initial source point
c locations associated with the D06 or D14 reactor core locations because
c there are not fuel elements in either of these reactor core locations.
c
c        x           y          z
c    -----------  -----------  -----------
      0.00000E+00  1.30607E+01  0.00000E+00 $ Fuel Element D01.
      3.76936E+00  1.08839E+01  0.00000E+00 $ Fuel Element D02.
      7.54126E+00  8.70712E+00  0.00000E+00 $ Fuel Element D03.
      1.13106E+01  6.53034E+00  0.00000E+00 $ Fuel Element D04.
      1.13106E+01  2.17678E+00  0.00000E+00 $ Fuel Element D05.
      1.13016E+01 -6.53034E+00  0.00000E+00 $ Fuel Element D07.
      7.54126E+00 -8.70712E+00  0.00000E+00 $ Fuel Element D08.
      3.76936E+00 -1.08839E+01  0.00000E+00 $ Fuel Element D09.
      0.00000E+00 -1.30607E+01  0.00000E+00 $ Fuel Element D10.
     -3.76936E+00 -1.08839E+01  0.00000E+00 $ Fuel Element D11.
     -7.54126E+00 -8.70712E+00  0.00000E+00 $ Fuel Element D12.
     -1.13016E+01 -6.53034E+00  0.00000E+00 $ Fuel Element D13.
     -1.13106E+01  2.17678E+00  0.00000E+00 $ Fuel Element D15.
     -1.13106E+01  6.53034E+00  0.00000E+00 $ Fuel Element D16.
     -7.54126E+00  8.70712E+00  0.00000E+00 $ Fuel Element D17.
     -3.76936E+00  1.08839E+01  0.00000E+00 $ Fuel Element D18.
c
c Specify the initial source point locations associated with the E-ring
c fuel elements. These initial source point locations are at the centers
c of the E-ring fuel elements. Note that there may or may not be not an
c initial source point location associated with the E11 reactor core
c location because there may or may not be a fuel element in the E11
c reactor core location depending on the reactor core configuration.
c If there is not a fuel element in reactor core location E11 the
c initial source point location associated with the E11 reactor
c core location should be commented out.
c
```

```
c        x           y          z
c    -----------  -----------  -----------
     0.00000E+00  1.74142E+01  0.00000E+00 $ Fuel Element E01.
     3.76936E+00  1.52375E+01  0.00000E+00 $ Fuel Element E02.
     7.54126E+00  1.30607E+01  0.00000E+00 $ Fuel Element E03.
     1.13106E+01  1.08839E+01  0.00000E+00 $ Fuel Element E04.
     1.50825E+01  8.70712E+00  0.00000E+00 $ Fuel Element E05.
     1.50825E+01  4.35356E+00  0.00000E+00 $ Fuel Element E06.
     1.50825E+01  0.00000E+00  0.00000E+00 $ Fuel Element E07.
     1.50825E+01 -4.35356E+00  0.00000E+00 $ Fuel Element E08.
     1.50825E+01 -8.70712E+00  0.00000E+00 $ Fuel Element E09.
     1.13106E+01 -1.08839E+01  0.00000E+00 $ Fuel Element E10.
c    7.54126E+00 -1.30607E+01  0.00000E+00 $ Fuel Element E11.
     3.76936E+00 -1.52375E+01  0.00000E+00 $ Fuel Element E12.
     0.00000E+00 -1.74142E+01  0.00000E+00 $ Fuel Element E13.
    -3.76936E+00 -1.52375E+01  0.00000E+00 $ Fuel Element E14.
    -7.54126E+00 -1.30607E+01  0.00000E+00 $ Fuel Element E15.
    -1.13106E+01 -1.08839E+01  0.00000E+00 $ Fuel Element E16.
    -1.50825E+01 -8.70712E+00  0.00000E+00 $ Fuel Element E17.
    -1.50825E+01 -4.35356E+00  0.00000E+00 $ Fuel Element E18.
    -1.50825E+01  0.00000E+00  0.00000E+00 $ Fuel Element E19.
    -1.50825E+01  4.35356E+00  0.00000E+00 $ Fuel Element E20.
    -1.50825E+01  8.70712E+00  0.00000E+00 $ Fuel Element E21.
    -1.13106E+01  1.08839E+01  0.00000E+00 $ Fuel Element E22.
    -7.54126E+00  1.30607E+01  0.00000E+00 $ Fuel Element E23.
    -3.76936E+00  1.52375E+01  0.00000E+00 $ Fuel Element E24.
c
c Specify the initial source point locations associated with the F-ring
c fuel elements. These initial source point locations are at the centers
c of the F-ring fuel elements. Note that there may or may not be initial
c source point locations associated with the F13 and F14 reactor core
c locations because there may or may not be fuel elements in these
c reactor core locations depending on the reactor core configuration.
c If there are not fuel elements in reactor core locations F13 or F14
c the initial source point location associated with the F13 and F14
c reactor core locations should be commented out.
c
c        x           y          z
c    -----------  -----------  -----------
     0.00000E+00  2.17678E+01  0.00000E+00 $ Fuel Element F01.
     3.76936E+00  1.95910E+01  0.00000E+00 $ Fuel Element F02.
     7.54126E+00  1.74142E+01  0.00000E+00 $ Fuel Element F03.
     1.13106E+01  1.52375E+01  0.00000E+00 $ Fuel Element F04.
     1.50825E+01  1.30607E+01  0.00000E+00 $ Fuel Element F05.
     1.88519E+01  1.08839E+01  0.00000E+00 $ Fuel Element F06.
     1.88519E+01  6.53034E+00  0.00000E+00 $ Fuel Element F07.
     1.88519E+01  2.17678E+00  0.00000E+00 $ Fuel Element F08.
     1.88519E+01 -2.17678E+00  0.00000E+00 $ Fuel Element F09.
     1.88519E+01 -6.53034E+00  0.00000E+00 $ Fuel Element F10.
     1.88519E+01 -1.08839E+01  0.00000E+00 $ Fuel Element F11.
     1.50825E+01 -1.30607E+01  0.00000E+00 $ Fuel Element F12.
c    1.13106E+01 -1.52375E+01  0.00000E+00 $ Fuel Element F13.
c    7.54126E+00 -1.74142E+01  0.00000E+00 $ Fuel Element F14.
     3.76936E+00 -1.95910E+01  0.00000E+00 $ Fuel Element F15.
     0.00000E+00 -2.17678E+01  0.00000E+00 $ Fuel Element F16.
    -3.76936E+00 -1.95910E+01  0.00000E+00 $ Fuel Element F17.
    -7.54126E+00 -1.74142E+01  0.00000E+00 $ Fuel Element F18.
    -1.13106E+01 -1.52375E+01  0.00000E+00 $ Fuel Element F19.
    -1.50825E+01 -1.30607E+01  0.00000E+00 $ Fuel Element F20.
    -1.88519E+01 -1.08839E+01  0.00000E+00 $ Fuel Element F21.
    -1.88519E+01 -6.53034E+00  0.00000E+00 $ Fuel Element F22.
    -1.88519E+01 -2.17678E+00  0.00000E+00 $ Fuel Element F23.
    -1.88519E+01  2.17678E+00  0.00000E+00 $ Fuel Element F24.
    -1.88519E+01  6.53034E+00  0.00000E+00 $ Fuel Element F25.
    -1.88519E+01  1.08839E+01  0.00000E+00 $ Fuel Element F26.
```

```
    -1.50825E+01  1.30607E+01  0.00000E+00 $ Fuel Element F27.
    -1.13106E+01  1.52375E+01  0.00000E+00 $ Fuel Element F28.
    -7.54126E+00  1.74142E+01  0.00000E+00 $ Fuel Element F29.
    -3.76936E+00  1.95910E+01  0.00000E+00 $ Fuel Element F30.
c
c Specify the initial source point locations associated with the G-ring
c fuel elements. These initial source point locations are at the centers
c of the G-ring fuel elements. Note that there are no initial source point
c locations associated with the G01, G07, G13, G19, G25, G31, G32, and G34
c reactor core locations because there are not fuel elements in any of
c these reactor core locations.
c
c        x           y           z
c    ----------- ----------- -----------
     3.76936E+00  2.39446E+01  0.00000E+00 $ Fuel Element G02.
     7.54126E+00  2.17678E+01  0.00000E+00 $ Fuel Element G03.
     1.13106E+01  1.95910E+01  0.00000E+00 $ Fuel Element G04.
     1.50825E+01  1.74142E+01  0.00000E+00 $ Fuel Element G05.
     1.88519E+01  1.52375E+01  0.00000E+00 $ Fuel Element G06.
     2.26212E+01  8.70712E+00  0.00000E+00 $ Fuel Element G08.
     2.26212E+01  4.35356E+00  0.00000E+00 $ Fuel Element G09.
     2.26212E+01  0.00000E+00  0.00000E+00 $ Fuel Element G10.
     2.26212E+01 -4.35356E+00  0.00000E+00 $ Fuel Element G11.
     2.26212E+01 -8.70712E+00  0.00000E+00 $ Fuel Element G12.
     1.88519E+01 -1.52375E+01  0.00000E+00 $ Fuel Element G14.
     1.50825E+01 -1.74142E+01  0.00000E+00 $ Fuel Element G15.
     1.13106E+01 -1.95910E+01  0.00000E+00 $ Fuel Element G16.
     7.54126E+00 -2.17678E+01  0.00000E+00 $ Fuel Element G17.
     3.76936E+00 -2.39446E+01  0.00000E+00 $ Fuel Element G18.
    -3.76936E+00 -2.39446E+01  0.00000E+00 $ Fuel Element G20.
    -7.54126E+00 -2.17678E+01  0.00000E+00 $ Fuel Element G21.
    -1.13106E+01 -1.95910E+01  0.00000E+00 $ Fuel Element G22.
    -1.50825E+01 -1.74142E+01  0.00000E+00 $ Fuel Element G23.
    -1.88519E+01 -1.52375E+01  0.00000E+00 $ Fuel Element G24.
    -2.26212E+01 -8.70712E+00  0.00000E+00 $ Fuel Element G26.
    -2.26212E+01 -4.35356E+00  0.00000E+00 $ Fuel Element G27.
    -2.26212E+01  0.00000E+00  0.00000E+00 $ Fuel Element G28.
    -2.26212E+01  4.35356E+00  0.00000E+00 $ Fuel Element G29.
    -2.26212E+01  8.70712E+00  0.00000E+00 $ Fuel Element G30.
    -1.50825E+01  1.74142E+01  0.00000E+00 $ Fuel Element G33.
    -7.54126E+00  2.17678E+01  0.00000E+00 $ Fuel Element G35.
    -3.76936E+00  2.39446E+01  0.00000E+00 $ Fuel Element G36.
c
c Request that tallies be evaluated:
c =================================
c
c e0: Specify the default energy bin structure to be used for all tallies:
c ------------------------------------------------------------------------
c
c Specify that the default energy bin structure to be used for
c all tallies should be the CINDER'90 63 energy bin structure.
c
c  e0   1.00000E-11 5.00000E-09 1.00000E-08 1.50000E-08 2.00000E-08 2.50000E-08
c       3.00000E-08 3.50000E-08 4.20000E-08 5.00000E-08 5.80000E-08 6.70000E-08
c       8.00000E-08 1.00000E-07 1.52000E-07 2.51000E-07 4.14000E-07 6.83000E-07
c       1.12500E-06 1.85500E-06 3.05900E-06 5.04300E-06 8.31500E-06 1.37100E-05
c       2.26000E-05 3.72700E-05 6.14400E-05 1.01300E-04 1.67000E-04 2.75400E-04
c       4.54000E-04 7.48500E-04 1.23400E-03 2.03500E-03 2.40400E-03 2.84000E-03
c       3.35500E-03 5.53100E-03 9.11900E-03 1.50300E-02 1.98900E-02 2.55400E-02
c       4.08700E-02 6.73800E-02 1.11100E-01 1.83200E-01 3.02000E-01 3.88700E-01
c       4.97900E-01 6.39279E-01 8.20850E-01 1.10803E+00 1.35335E+00 1.73774E+00
c       2.23130E+00 2.86505E+00 3.67879E+00 4.96585E+00 6.06500E+00 1.00000E+01
c       1.49182E+01 1.69046E+01 2.00000E+01 2.50000E+01
c
c The following energy bin structure is that for the 238 energy group such that
```

```
c ORIGEN/SCALE calculations can be performed to determine fission yields and such.
c
E0   1.000E-11 1.0000E-10 5.0000E-10 7.5000E-10 1.0000E-09 1.2000E-09 1.5000E-09
     2.000E-09 2.5000E-09 3.0000E-09 4.0000E-09 5.0000E-09 7.5000E-09 1.0000E-08
     2.530E-08 3.0000E-08 4.0000E-08 5.0000E-08 6.0000E-08 7.0000E-08 8.0000E-08
     9.000E-08 1.0000E-07 1.2500E-07 1.5000E-07 1.7500E-07 2.0000E-07 2.2500E-07
     2.500E-07 2.7500E-07 3.0000E-07 3.2500E-07 3.5000E-07 3.7500E-07 4.0000E-07
     4.500E-07 5.0000E-07 5.5000E-07 6.0000E-07 6.2500E-07 6.5000E-07 7.0000E-07
     7.500E-07 8.0000E-07 8.5000E-07 9.0000E-07 9.2500E-07 9.5000E-07 9.7500E-07
     1.000E-06 1.0100E-06 1.0200E-06 1.0300E-06 1.0400E-06 1.0500E-06 1.0600E-06
     1.070E-06 1.0800E-06 1.0900E-06 1.1000E-06 1.1100E-06 1.1200E-06 1.1300E-06
     1.140E-06 1.1500E-06 1.1750E-06 1.2000E-06 1.2250E-06 1.2500E-06 1.3000E-06
     1.350E-06 1.4000E-06 1.4500E-06 1.5000E-06 1.5900E-06 1.6800E-06 1.7700E-06
     1.860E-06 1.9400E-06 2.0000E-06 2.1200E-06 2.2100E-06 2.3000E-06 2.3800E-06
     2.470E-06 2.5700E-06 2.6700E-06 2.7700E-06 2.8700E-06 2.9700E-06 3.0000E-06
     3.050E-06 3.1500E-06 3.5000E-06 3.7300E-06 4.0000E-06 4.7500E-06 5.0000E-06
     5.400E-06 6.0000E-06 6.2500E-06 6.5000E-06 6.7500E-06 7.0000E-06 7.1500E-06
     8.100E-06 9.1000E-06 1.0000E-05 1.1500E-05 1.1900E-05 1.2900E-05 1.3750E-05
     1.440E-05 1.5100E-05 1.6000E-05 1.7000E-05 1.8500E-05 1.9000E-05 2.0000E-05
     2.100E-05 2.2500E-05 2.5000E-05 2.7500E-05 3.0000E-05 3.1250E-05 3.1750E-05
     3.325E-05 3.3750E-05 3.4600E-05 3.5500E-05 3.7000E-05 3.8000E-05 3.9100E-05
     3.960E-05 4.1000E-05 4.2400E-05 4.4000E-05 4.5200E-05 4.7000E-05 4.8300E-05
     4.920E-05 5.0600E-05 5.2000E-05 5.3400E-05 5.9000E-05 6.1000E-05 6.5000E-05
     6.750E-05 7.2000E-05 7.6000E-05 8.0000E-05 8.2000E-05 9.0000E-05 1.0000E-04
     1.080E-04 1.1500E-04 1.1900E-04 1.2200E-04 1.8600E-04 1.9250E-04 2.0750E-04
     2.100E-04 2.4000E-04 2.8500E-04 3.0500E-04 5.5000E-04 6.7000E-04 6.8300E-04
     9.500E-04 1.1500E-03 1.5000E-03 1.5500E-03 1.8000E-03 2.2000E-03 2.2900E-03
     2.580E-03 3.0000E-03 3.7400E-03 3.9000E-03 6.0000E-03 8.0300E-03 9.5000E-03
     1.300E-02 1.7000E-02 2.5000E-02 3.0000E-02 4.5000E-02 5.0000E-02 5.2000E-02
     6.000E-02 7.3000E-02 7.5000E-02 8.2000E-02 8.5000E-02 1.0000E-01 1.2830E-01
     1.500E-01 2.0000E-01 2.7000E-01 3.3000E-01 4.0000E-01 4.2000E-01 4.4000E-01
     4.700E-01 4.9952E-01 5.5000E-01 5.7300E-01 6.0000E-01 6.7000E-01 6.7900E-01
     7.500E-01 8.2000E-01 8.6110E-01 8.7500E-01 9.0000E-01 9.2000E-01 1.0100E+00
     1.100E+00 1.2000E+00 1.2500E+00 1.3170E+00 1.3560E+00 1.4000E+00 1.5000E+00
     1.850E+00 2.3540E+00 2.4790E+00 3.0000E+00 4.3040E+00 4.8000E+00 6.4340E+00
     8.1873E+0 1.0000E+01 1.2840E+01 1.3840E+01 1.4550E+01 1.5683E+01 1.7333E+01
     2.000E+01
c
c Evaluate tallies in the central body section of the Swagelok PFA plug valve:
c ---------------------------------------------------------------------------
c
c Request a tally to evaluate the neutron flux profile in the gas trapped
c in the central body section of the Swagelok PFA plug valve (cell 0253):
c
c F0004:n 0253
c FC0004 The neutron flux profile in cell 0253.
c SD0004 0.167 $ This segment divisor card specifies that the volume of cell 0253
c            is 0.167 cm^3. The volume of cell 0253 is calculated in the
c            Excel workbook having the following file name:
c            Swagelok_PFA_Plug_Valve_Surface_Position_Calculations.xlsx
c
c Request a tally to evaluate the cross-section weighted neutron flux
c profile in the gas trapped in the central body section of the
c Swagelok PFA plug valve (cell 0253):
c
c F0014:n 0253
c FC0014 Cross-section weighted neutron flux profile in cell 0253.
c FM0014 1 12 102 $ This tally multiplier card specifies that the multiplicative
c              constant should be one, the MCNP material number associated
c              with the material filling cell 0253 should be 30, and the
c              reaction number of interest should be 102 (the radiative
c              capture reaction number).
c SD0014 0.167 $ This segment divisor card specifies that the volume of cell 0253
c            is 0.167 cm^3. The volume of cell 0253 is calculated in the
c            Excel workbook having the following file name:
```

```
c           Swagelok_PFA_Plug_Valve_Surface_Position_Calculations.xlsx
c
c Evaluate tallies in the end-cap section of the Swagelok PFA plug valve:
c -----------------------------------------------------------------------
c
c Request a tally to evaluate the neutron flux profile in the gas trapped
c in the end-cap section of the Swagelok PFA plug valve (cell 0251):
c
c F0024:n 0251
c FC0024 The neutron flux profile in cell 0251.
c SD0024 0.438 $ This segment divisor card specifies that the volume of cell 0251
c           is 0.438 cm^3. The volume of cell 0253 is calculated in the
c           Excel workbook having the following file name:
c           Swagelok_PFA_Plug_Valve_Surface_Position_Calculations.xlsx
c
c Request a tally to evaluate the cross-section weighted neutron flux
c profile in the gas trapped in the end-cap section of the
c Swagelok PFA plug valve (cell 0251):
c
c F0034:n 0251
c FC0034 Cross-section weighted neutron flux profile in cell 0251.
c FM0034 1 12 102 $ This tally multiplier card specifies that the multiplicative
c             constant should be one, the MCNP material number associated
c             with the material filling cell 0251 should be 30, and the
c             reaction number of interest should be 102 (the radiative
c             capture reaction number).
c SD0034 0.438 $ This segment divisor card specifies that the volume of cell 0251
c           is 0.438 cm^3. The volume of cell 0253 is calculated in the
c           Excel workbook having the following file name:
c           Swagelok_PFA_Plug_Valve_Surface_Position_Calculations.xlsx
c
c
c FLUX TALLIES FOR BRANDON
F0174:N  0705
F0184:N  0706
+F0016   0796
+F0026   0797
+F0036   0799
+F0046   0800
+F0056   0801
+F0066   0696
+F0076   0699
+F0086   0700
+F0096   0701
+F0116   0702
+F0126   0703
+F0136   0704
+F0146   0705
+F0156   0706
+F0166   0707
+F0176   0708
+F0186   0709
+F0196   0710
+F0216   0711
+F0226   0712
+F0236   0713
+F0246   0714
c
c WWP and WWG: Set weight-window parameter and weight-window generator options:
c ==============================================================================
c
c Set the particle designator keyword on the WWP card equal to N and set the
c "switchn" keyword on the WWP card equal to -1 to specify that the lower
c weight bounds for neutrons should be extracted from an external WWINP file.
c Accept the defaults for all of the other WWP card keywords.
```

```
c
WWP:N 4J -1 4J
c
c Set the "it" keyword on the WWG card equal to 0024 to specify that the
c weight-window generator should be optimized for tally number 0024 (the neutron
c flux profile tally evaluated in the gas trapped in the central body section of
c the Swagelok PFA plug valve). Also set the "ic" keyword equal to 0016 to
c specify that the cell based weight-window generator should be invoked with
c cell 0016 as the reference cell (the fact that the reference cell is specified
c as a positive number indicates that the cell-based weight-window generator
c should be invoked). Accept the defaults for all of the other
c WWG card keywords.
c
WWG 0184 0016 6J
c
c PRINT: Request that optional output tables be printed:
c ======================================================
c
c Request that optional print table 128, the universe map table, be printed.
c This table must be printed to allow MCNP to determine if all repeated
c structures and lattice elements are sampled for fission neutron
c source points.
c
PRINT 128
c
c RAND: Set the psuedorandom number generation options:
c =====================================================
c
c Set the "GEN" keyword on the RAND card equal to 1 to specify that the MCNP
c Lehmer 48-bit congruential psuedorandom number generator should be used
c (this is the default psuedorandom number generator in MCNP 6.1.1b). Also,
c set the "SEED" keyword on the RAND card equal to 219,008,682,294,439 to set
c the psuedorandom number generator seed equal to 219,008,682,294,439.
c Accept the defaults for all the other RAND card keywords.
c
c Note that originally the default values were accepted for all of the RAND
c card keywords, but the execution of this MCNP input deck terminated because
c of "bad trouble" in the rotas subroutine encountered during the transport of
c particle history number 1,6096,186, which utilized a starting psuedorandom
c number of 219,008,682,294,437. I discussed this issue with Dr. Forrest Brown
c at Los Alamos National Lab in an email chain that originated on
c 10 November 2015. While the root issue in the rotas subroutine was not
c identified or flushed out, Dr. Brown agreed that setting the psuedorandom
c number seed manually might provide a work around. The "SEED" keyword is thus
c now set equal to the odd number immediately following the starting
c psuedorandom number associated with the offending particle history in an
c attempt to work around the aforementioned bad trouble encountered when the
c default values were accepted for all of the RAND card keywords.
c
RAND GEN=1 SEED=219008682294439
```

SCALE Input Files

KENO-VI Input File

```
' the MAKE_f33_current_with_3el retains TEMP directory with ft33f001.cmbined
=t6-depl parm=(addnux=4)
ut triga core at 600 k, 87 elements
ce_v7.1
read composition
 zirconium   1 1     293   end
 h2o         2 1     293   end
```

```
 ss304s      3 1     293   end
'
 graphite    4 1     293   end
 aluminum    5 1     293   end
 dry-air     6 1     293   end
 b4c         7 0.984 293   end
 h           8 8.2E-5 293  end
 mo          9 1     293   end
' 3EL draft by Brandon A. De Luna
 cd     11 den=8.65  1  293   end
 ag      12 den=10.49 1  293   end
 b       13 den=1.55  1  293 5010 96.0 5011 4.0 end
 pyrex       14 den=2.203 1  293   end
 b4c     16 den=1.46  1 293 end
' 3EL experimental portion
 u-235     15 den=19.1 1 293 92235 100.0 end
' uo2     15 den=10.97 1 293 92235 90.0 92238 10.0 8016 100.0 end
' ar-36       12 0  1.38E-5  293   end
' xe-126      12 0  1.12E-5  293   end
' 2985   ρ= 5.8115  4.911751
  h-zrh2 2985 0.093130566  300 END
  u-235 2985 0.079334492  300 END
  u-238 2985 0.370420631  300 END
  zr-90 2985 2.710080518  300 END
  zr-91 2985 0.591081541  300 END
  zr-92 2985 0.903813221  300 END
  zr-94 2985 0.91585877  300 END
  zr-96 2985 0.147798165  300 END
  U-236 2985 0.001979927  300 END
  Pu-239 2985 0.000367887  300 END
  Pu-240 2985 2.63013E-05  300 END
  Pu-241 2985 3.28824E-08  300 END
  Np-237 2985 3.46866E-06  300 END
  Kr-83 2985 2.00792E-05  300 END
  I-129 2985 3.35438E-05  300 END
  I-131 2985 1.97677E-05  300 END
  Xe-131 2985 0.000166489  300 END
  Xe-133 2985 2.65156E-05  300 END
  Xe-135 2985 3.0607E-11  300 END
  Mo-95 2985 4.25097E-05  300 END
  Mo-97 2985 0.000291267  300 END
  Tc-99 2985 0.000297303  300 END
  Ru-101 2985 0.000256708  300 END
  Rh-103 2985 7.2695E-05  300 END
  Rh-105 2985 6.89116E-08  300 END
  Pd-105 2985 4.51292E-05  300 END
  Cd-113 2985 7.46497E-08  300 END
  Cs-133 2985 0.00041797  300 END
  Cs-134 2985 1.87211E-06  300 END
  La-139 2985 0.000435839  300 END
  Ce-141 2985 0.000185501  300 END
  Pr-141 2985 0.000215414  300 END
  Pr-143 2985 9.52093E-05  300 END
  Nd-143 2985 0.000325944  300 END
  Nd-145 2985 0.000272484  300 END
  Nd-147 2985 2.51901E-05  300 END
  Pm-147 2985 0.000272484  300 END
  Pm-149 2985 5.01171E-07  300 END
  Sm-149 2985 7.62111E-06  300 END
  Sm-150 2985 7.20741E-05  300 END
  Sm-151 2985 1.2071E-05  300 END
  Sm-152 2985 4.01664E-05  300 END
  Eu-153 2985 1.21249E-05  300 END
  Eu-154 2985 3.69312E-07  300 END
  Eu-155 2985 1.56723E-06  300 END
```

Gd-155 2985 7.93296E-09 300 END
Gd-157 2985 2.14672E-08 300 END

' 3384   ρ= 6.1491 MWD= 4.575537435
h-zrh2 3384 0.098517736 300 END
u-235 3384 0.083519091 300 END
u-238 3384 0.393823739 300 END
zr-90 3384 2.866853093 300 END
zr-91 3384 0.625268321 300 END
zr-92 3384 0.956049554 300 END
zr-94 3384 0.968801775 300 END
zr-96 3384 0.156310489 300 END
U-236 3384 0.001844399 300 END
Pu-239 3384 0.000346206 300 END
Pu-240 3384 2.29025E-05 300 END
Pu-241 3384 3.07255E-08 300 END
Np-237 3384 3.00689E-06 300 END
Kr-83 3384 1.87048E-05 300 END
I-129 3384 3.12477E-05 300 END
I-131 3384 1.96084E-05 300 END
Xe-131 3384 0.000155092 300 END
Xe-133 3384 2.64613E-05 300 END
Xe-135 3384 3.06971E-11 300 END
Mo-95 3384 3.64915E-05 300 END
Mo-97 3384 0.000271329 300 END
Tc-99 3384 0.000276953 300 END
Ru-101 3384 0.000239136 300 END
Rh-103 3384 6.53716E-05 300 END
Rh-105 3384 6.88879E-08 300 END
Pd-105 3384 4.204E-05 300 END
Cd-113 3384 7.51505E-08 300 END
Cs-133 3384 0.00038936 300 END
Cs-134 3384 1.6107E-06 300 END
La-139 3384 0.000406006 300 END
Ce-141 3384 0.000179201 300 END
Pr-141 3384 0.000194557 300 END
Pr-143 3384 9.37404E-05 300 END
Nd-143 3384 0.000303633 300 END
Nd-145 3384 0.000253833 300 END
Nd-147 3384 2.49072E-05 300 END
Pm-147 3384 0.000253833 300 END
Pm-149 3384 4.98824E-07 300 END
Sm-149 3384 7.61405E-06 300 END
Sm-150 3384 6.68991E-05 300 END
Sm-151 3384 1.18601E-05 300 END
Sm-152 3384 3.72629E-05 300 END
Eu-153 3384 1.11825E-05 300 END
Eu-154 3384 3.16185E-07 300 END
Eu-155 3384 1.50109E-06 300 END
Gd-155 3384 7.58291E-09 300 END
Gd-157 3384 2.14522E-08 300 END

' 10878   ρ= 6.0909 MWD= 3.979852669
h-zrh2 10878 0.097560916 300 END
u-235 10878 0.08475279 300 END
u-238 10878 0.389556808 300 END
zr-90 10878 2.83901651 300 END
zr-91 10878 0.619189616 300 END
zr-92 10878 0.946723703 300 END
zr-94 10878 0.959361365 300 END
zr-96 10878 0.154759397 300 END
U-236 10878 0.001604279 300 END
Pu-239 10878 0.000306387 300 END
Pu-240 10878 1.74416E-05 300 END
Pu-241 10878 2.68735E-08 300 END

Np-237 10878 2.27452E-06 300 END
Kr-83 10878 1.62696E-05 300 END
I-129 10878 2.71796E-05 300 END
I-131 10878 1.92365E-05 300 END
Xe-131 10878 0.000134901 300 END
Xe-133 10878 2.62843E-05 300 END
Xe-135 10878 3.08502E-11 300 END
Mo-95 10878 2.70057E-05 300 END
Mo-97 10878 0.000236005 300 END
Tc-99 10878 0.000240897 300 END
Ru-101 10878 0.000208003 300 END
Rh-103 10878 5.2941E-05 300 END
Rh-105 10878 6.88101E-08 300 END
Pd-105 10878 3.65669E-05 300 END
Cd-113 10878 7.58705E-08 300 END
Cs-133 10878 0.00033867 300 END
Cs-134 10878 1.2016E-06 300 END
La-139 10878 0.000353148 300 END
Ce-141 10878 0.000166511 300 END
Pr-141 10878 0.000159049 300 END
Pr-143 10878 9.04901E-05 300 END
Nd-143 10878 0.000264103 300 END
Nd-145 10878 0.000220786 300 END
Nd-147 10878 2.42605E-05 300 END
Pm-147 10878 0.000220786 300 END
Pm-149 10878 4.94406E-07 300 END
Sm-149 10878 7.58927E-06 300 END
Sm-150 10878 5.78175E-05 300 END
Sm-151 10878 1.13865E-05 300 END
Sm-152 10878 3.21743E-05 300 END
Eu-153 10878 9.55328E-06 300 END
Eu-154 10878 2.32947E-07 300 END
Eu-155 10878 1.37684E-06 300 END
Gd-155 10878 6.92748E-09 300 END
Gd-157 10878 2.14193E-08 300 END

' 3013 ρ= 5.9508 MWD= 6.09527036
h-zrh2 3013 0.095409087 300 END
u-235 3013 0.076784714 300 END
u-238 3013 0.380828558 300 END
zr-90 3013 2.776370035 300 END
zr-91 3013 0.605559081 300 END
zr-92 3013 0.926005837 300 END
zr-94 3013 0.938326332 300 END
zr-96 3013 0.151477792 300 END
U-236 3013 0.002457003 300 END
Pu-239 3013 0.000439711 300 END
Pu-240 3013 4.00659E-05 300 END
Pu-241 3013 4.03785E-08 300 END
Np-237 3013 5.3833E-06 300 END
Kr-83 3013 2.49175E-05 300 END
I-129 3013 4.16264E-05 300 END
I-131 3013 2.0126E-05 300 END
Xe-131 3013 0.000206605 300 END
Xe-133 3013 2.65328E-05 300 END
Xe-135 3013 3.02748E-11 300 END
Mo-95 3013 6.75152E-05 300 END
Mo-97 3013 0.00036145 300 END
Tc-99 3013 0.000368941 300 END
Ru-101 3013 0.000318563 300 END
Rh-103 3013 9.99439E-05 300 END
Rh-105 3013 6.89083E-08 300 END
Pd-105 3013 5.60033E-05 300 END
Cd-113 3013 7.2582E-08 300 END
Cs-133 3013 0.000518683 300 END

Cs-134 3013 2.9799E-06 300 END
La-139 3013 0.000540858 300 END
Ce-141 3013 0.00020358 300 END
Pr-141 3013 0.000292867 300 END
Pr-143 3013 9.88382E-05 300 END
Nd-143 3013 0.000404482 300 END
Nd-145 3013 0.000338141 300 END
Nd-147 3013 2.58495E-05 300 END
Pm-147 3013 0.000338141 300 END
Pm-149 3013 5.08902E-07 300 END
Sm-149 3013 7.6198E-06 300 END
Sm-150 3013 9.05729E-05 300 END
Sm-151 3013 1.25702E-05 300 END
Sm-152 3013 5.05671E-05 300 END
Eu-153 3013 1.5574E-05 300 END
Eu-154 3013 5.92594E-07 300 END
Eu-155 3013 1.78283E-06 300 END
Gd-155 3013 9.07806E-09 300 END
Gd-157 3013 2.15071E-08 300 END

' 2899 ρ= 5.8814 MWD= 4.994277404
h-zrh2 2899 0.094251052 300 END
u-235 2899 0.080225158 300 END
u-238 2899 0.374874179 300 END
zr-90 2899 2.742685919 300 END
zr-91 2899 0.598193929 300 END
zr-92 2899 0.914689221 300 END
zr-94 2899 0.926879104 300 END
zr-96 2899 0.149577776 300 END
U-236 2899 0.002013193 300 END
Pu-239 2899 0.000373121 300 END
Pu-240 2899 2.71703E-05 300 END
Pu-241 2899 3.341E-08 300 END
Np-237 2899 3.58744E-06 300 END
Kr-83 2899 2.04166E-05 300 END
I-129 2899 3.41074E-05 300 END
I-131 2899 1.98021E-05 300 END
Xe-131 2899 0.000169286 300 END
Xe-133 2899 2.65249E-05 300 END
Xe-135 2899 3.05845E-11 300 END
Mo-95 2899 4.40604E-05 300 END
Mo-97 2899 0.000296161 300 END
Tc-99 2899 0.000302299 300 END
Ru-101 2899 0.000261021 300 END
Rh-103 2899 7.45236E-05 300 END
Rh-105 2899 6.89155E-08 300 END
Pd-105 2899 4.58874E-05 300 END
Cd-113 2899 7.45191E-08 300 END
Cs-133 2899 0.000424993 300 END
Cs-134 2899 1.93976E-06 300 END
La-139 2899 0.000443162 300 END
Ce-141 2899 0.00018696 300 END
Pr-141 2899 0.000220617 300 END
Pr-143 2899 9.55354E-05 300 END
Nd-143 2899 0.00033142 300 END
Nd-145 2899 0.000277063 300 END
Nd-147 2899 2.52519E-05 300 END
Pm-147 2899 0.000277063 300 END
Pm-149 2899 5.01734E-07 300 END
Sm-149 2899 7.62223E-06 300 END
Sm-150 2899 7.33497E-05 300 END
Sm-151 2899 1.21174E-05 300 END
Sm-152 2899 4.08825E-05 300 END
Eu-153 2899 1.23588E-05 300 END
Eu-154 2899 3.83039E-07 300 END

```
 Eu-155 2899 1.58308E-06  300 END
 Gd-155 2899 8.01697E-09  300 END
 Gd-157 2899 2.14706E-08  300 END

' 10809   ρ= 6.234 MWD= 0
 h-zrh2 10809 0.099680391  300 END
 u-235 10809 0.09772232  300 END
 u-238 10809 0.398330067  300 END
 zr-90 10809 2.900730298  300 END
 zr-91 10809 0.632632217  300 END
 zr-92 10809 0.967004075  300 END
 zr-94 10809 0.979972642  300 END
 zr-96 10809 0.157878216  300 END
 U-236 10809 0 1.00E-20 300 END
 Pu-239 10809 0 1.00E-20 300 END
 Pu-240 10809 0 1.00E-20 300 END
 Pu-241 10809 0 1.00E-20 300 END
 Np-237 10809 0 1.00E-20 300 END
 Kr-83 10809 0 1.00E-20 300 END
 I-129 10809 0 1.00E-20 300 END
 I-131 10809 0 1.00E-20 300 END
 Xe-131 10809 0 1.00E-20 300 END
 Xe-133 10809 0 1.00E-20 300 END
 Xe-135 10809 0 1.00E-20 300 END
 Mo-95 10809 1E-11  300 END
 Mo-97 10809 0 1.00E-20 300 END
 Tc-99 10809 0 1.00E-20 300 END
 Ru-101 10809 0 1.00E-20 300 END
 Rh-103 10809 0 1.00E-20 300 END
 Rh-105 10809 0 1.00E-20 300 END
 Pd-105 10809 0 1.00E-20 300 END
 Cd-113 10809 1E-17  300 END
 Cs-133 10809 0 1.00E-20 300 END
 Cs-134 10809 0 1.00E-20 300 END
 La-139 10809 0 1.00E-20 300 END
 Ce-141 10809 0 1.00E-20 300 END
 Pr-141 10809 0 1.00E-20 300 END
 Pr-143 10809 0 1.00E-20 300 END
 Nd-143 10809 0 1.00E-20 300 END
 Nd-145 10809 0 1.00E-20 300 END
 Nd-147 10809 0 1.00E-20 300 END
 Pm-147 10809 0 1.00E-20 300 END
 Pm-149 10809 0 1.00E-20 300 END
 Sm-149 10809 0 1.00E-20 300 END
 Sm-150 10809 0 1.00E-20 300 END
 Sm-151 10809 1E-13  300 END
 Sm-152 10809 0 1.00E-20 300 END
 Eu-153 10809 0 1.00E-20 300 END
 Eu-154 10809 0 1.00E-20 300 END
 Eu-155 10809 1E-13  300 END
 Gd-155 10809 1E-15  300 END
 Gd-157 10809 1.94991E-15  300 END

' 2965   ρ= 5.91 MWD= 4.653013732
 h-zrh2 2965 0.094694034  300 END
 u-235 2965 0.081595871  300 END
 u-238 2965 0.376672826  300 END
 zr-90 2965 2.755581208  300 END
 zr-91 2965 0.60100134  300 END
 zr-92 2965 0.918961358  300 END
 zr-94 2965 0.931214787  300 END
 zr-96 2965 0.150258975  300 END
 U-236 2965 0.00187563  300 END
 Pu-239 2965 0.000351253  300 END
 Pu-240 2965 2.36656E-05  300 END
```

Pu-241 2965 3.12236E-08 300 END
Np-237 2965 3.11016E-06 300 END
Kr-83 2965 1.90215E-05 300 END
I-129 2965 3.17768E-05 300 END
I-131 2965 1.96479E-05 300 END
Xe-131 2965 0.000157719 300 END
Xe-133 2965 2.64763E-05 300 END
Xe-135 2965 3.06766E-11 300 END
Mo-95 2965 3.78357E-05 300 END
Mo-97 2965 0.000275924 300 END
Tc-99 2965 0.000281642 300 END
Ru-101 2965 0.000243185 300 END
Rh-103 2965 6.70407E-05 300 END
Rh-105 2965 6.88945E-08 300 END
Pd-105 2965 4.27519E-05 300 END
Cd-113 2965 7.504E-08 300 END
Cs-133 2965 0.000395953 300 END
Cs-134 2965 1.66894E-06 300 END
La-139 2965 0.000412881 300 END
Ce-141 2965 0.000180705 300 END
Pr-141 2965 0.000199314 300 END
Pr-143 2965 9.40999E-05 300 END
Nd-143 2965 0.000308774 300 END
Nd-145 2965 0.000258131 300 END
Nd-147 2965 2.4977E-05 300 END
Pm-147 2965 0.000258131 300 END
Pm-149 2965 4.99373E-07 300 END
Sm-149 2965 7.61605E-06 300 END
Sm-150 2965 6.80885E-05 300 END
Sm-151 2965 1.1912E-05 300 END
Sm-152 2965 3.793E-05 300 END
Eu-153 2965 1.13982E-05 300 END
Eu-154 2965 3.28031E-07 300 END
Eu-155 2965 1.51656E-06 300 END
Gd-155 2965 7.66474E-09 300 END
Gd-157 2965 2.14558E-08 300 END

' 2984   ρ= 5.8827 MWD= 4.485471539
h-zrh2 2984 0.094251052 300 END
u-235 2984 0.081611298 300 END
u-238 2984 0.374925577 300 END
zr-90 2984 2.742692364 300 END
zr-91 2984 0.598188005 300 END
zr-92 2984 0.914651616 300 END
zr-94 2984 0.926850263 300 END
zr-96 2984 0.149547337 300 END
U-236 2984 0.001808094 300 END
Pu-239 2984 0.000340301 300 END
Pu-240 2984 2.20308E-05 300 END
Pu-241 2984 3.01456E-08 300 END
Np-237 2984 2.88918E-06 300 END
Kr-83 2984 1.83366E-05 300 END
I-129 2984 3.06326E-05 300 END
I-131 2984 1.95601E-05 300 END
Xe-131 2984 0.00015204 300 END
Xe-133 2984 2.64417E-05 300 END
Xe-135 2984 3.07208E-11 300 END
Mo-95 2984 3.49608E-05 300 END
Mo-97 2984 0.000265988 300 END
Tc-99 2984 0.000271501 300 END
Ru-101 2984 0.000234429 300 END
Rh-103 2984 6.34458E-05 300 END
Rh-105 2984 6.88792E-08 300 END
Pd-105 2984 4.12125E-05 300 END
Cd-113 2984 7.52747E-08 300 END

Cs-133 2984 0.000381696 300 END
Cs-134 2984 1.54447E-06 300 END
La-139 2984 0.000398014 300 END
Ce-141 2984 0.000177413 300 END
Pr-141 2984 0.000189066 300 END
Pr-143 2984 9.33056E-05 300 END
Nd-143 2984 0.000297656 300 END
Nd-145 2984 0.000248836 300 END
Nd-147 2984 2.48222E-05 300 END
Pm-147 2984 0.000248836 300 END
Pm-149 2984 4.9818E-07 300 END
Sm-149 2984 7.6114E-06 300 END
Sm-150 2984 6.55189E-05 300 END
Sm-151 2984 1.17972E-05 300 END
Sm-152 2984 3.6489E-05 300 END
Eu-153 2984 1.09328E-05 300 END
Eu-154 2984 3.02712E-07 300 END
Eu-155 2984 1.48291E-06 300 END
Gd-155 2984 7.48686E-09 300 END
Gd-157 2984 2.14478E-08 300 END

' 2944   ρ= 5.9493 MWD= 4.558305257
h-zrh2 2944 0.095319421 300 END
u-235 2944 0.082476486 300 END
u-238 2944 0.379172733 300 END
zr-90 2944 2.773781351 300 END
zr-91 2944 0.604969415 300 END
zr-92 2944 0.925021283 300 END
zr-94 2944 0.937357692 300 END
zr-96 2944 0.151243825 300 END
U-236 2944 0.001837453 300 END
Pu-239 2944 0.00034508 300 END
Pu-240 2944 2.27345E-05 300 END
Pu-241 2944 3.06146E-08 300 END
Np-237 2944 2.98418E-06 300 END
Kr-83 2944 1.86344E-05 300 END
I-129 2944 3.113E-05 300 END
I-131 2944 1.95993E-05 300 END
Xe-131 2944 0.000154508 300 END
Xe-133 2944 2.64577E-05 300 END
Xe-135 2944 3.07017E-11 300 END
Mo-95 2944 3.6196E-05 300 END
Mo-97 2944 0.000270308 300 END
Tc-99 2944 0.00027591 300 END
Ru-101 2944 0.000238235 300 END
Rh-103 2944 6.5002E-05 300 END
Rh-105 2944 6.88863E-08 300 END
Pd-105 2944 4.18817E-05 300 END
Cd-113 2944 7.51746E-08 300 END
Cs-133 2944 0.000387894 300 END
Cs-134 2944 1.5979E-06 300 END
La-139 2944 0.000404477 300 END
Ce-141 2944 0.000178863 300 END
Pr-141 2944 0.000193503 300 END
Pr-143 2944 9.36586E-05 300 END
Nd-143 2944 0.000302489 300 END
Nd-145 2944 0.000252877 300 END
Nd-147 2944 2.48913E-05 300 END
Pm-147 2944 0.000252877 300 END
Pm-149 2944 4.98701E-07 300 END
Sm-149 2944 7.61357E-06 300 END
Sm-150 2944 6.66348E-05 300 END
Sm-151 2944 1.18483E-05 300 END
Sm-152 2944 3.71147E-05 300 END
Eu-153 2944 1.11346E-05 300 END

Eu-154 2944 3.13583E-07 300 END
Eu-155 2944 1.49763E-06 300 END
Gd-155 2944 7.56461E-09 300 END
Gd-157 2944 2.14513E-08 300 END

' 2931 ρ= 5.8807 MWD= 4.030988609
h-zrh2 2931 0.094198936 300 END
u-235 2931 0.082797562 300 END
u-238 2931 0.374762891 300 END
zr-90 2931 2.741181261 300 END
zr-91 2931 0.597852648 300 END
zr-92 2931 0.914112717 300 END
zr-94 2931 0.926312145 300 END
zr-96 2931 0.149437604 300 END
U-236 2931 0.001624892 300 END
Pu-239 2931 0.000309876 300 END
Pu-240 2931 1.78821E-05 300 END
Pu-241 2931 2.72057E-08 300 END
Np-237 2931 2.33315E-06 300 END
Kr-83 2931 1.64787E-05 300 END
I-129 2931 2.75288E-05 300 END
I-131 2931 1.92737E-05 300 END
Xe-131 2931 0.000136634 300 END
Xe-133 2931 2.63044E-05 300 END
Xe-135 2931 3.08375E-11 300 END
Mo-95 2931 2.77612E-05 300 END
Mo-97 2931 0.000239038 300 END
Tc-99 2931 0.000243992 300 END
Ru-101 2931 0.000210676 300 END
Rh-103 2931 5.39787E-05 300 END
Rh-105 2931 6.88188E-08 300 END
Pd-105 2931 3.70367E-05 300 END
Cd-113 2931 7.58193E-08 300 END
Cs-133 2931 0.000343021 300 END
Cs-134 2931 1.23408E-06 300 END
La-139 2931 0.000357686 300 END
Ce-141 2931 0.000167683 300 END
Pr-141 2931 0.00016202 300 END
Pr-143 2931 9.08064E-05 300 END
Nd-143 2931 0.000267496 300 END
Nd-145 2931 0.000223623 300 END
Nd-147 2931 2.43245E-05 300 END
Pm-147 2931 0.000223623 300 END
Pm-149 2931 4.94801E-07 300 END
Sm-149 2931 7.59214E-06 300 END
Sm-150 2931 5.85928E-05 300 END
Sm-151 2931 1.14328E-05 300 END
Sm-152 2931 3.26084E-05 300 END
Eu-153 2931 9.6911E-06 300 END
Eu-154 2931 2.39553E-07 300 END
Eu-155 2931 1.3879E-06 300 END
Gd-155 2931 6.98572E-09 300 END
Gd-157 2931 2.14225E-08 300 END

' 2983 ρ= 5.9723 MWD= 4.508325939
h-zrh2 2983 0.095684231 300 END
u-235 2983 0.082975828 300 END
u-238 2983 0.380630466 300 END
zr-90 2983 2.78439803 300 END
zr-91 2983 0.607284196 300 END
zr-92 2983 0.928556632 300 END
zr-94 2983 0.940941351 300 END
zr-96 2983 0.151818636 300 END
U-236 2983 0.001817306 300 END
Pu-239 2983 0.000341804 300 END

Pu-240 2983 2.22504E-05 300 END
Pu-241 2983 3.02928E-08 300 END
Np-237 2983 2.91881E-06 300 END
Kr-83 2983 1.843E-05 300 END
I-129 2983 3.07887E-05 300 END
I-131 2983 1.95726E-05 300 END
Xe-131 2983 0.000152814 300 END
Xe-133 2983 2.64469E-05 300 END
Xe-135 2983 3.07148E-11 300 END
Mo-95 2983 3.5346E-05 300 END
Mo-97 2983 0.000267344 300 END
Tc-99 2983 0.000272884 300 END
Ru-101 2983 0.000235623 300 END
Rh-103 2983 6.3933E-05 300 END
Rh-105 2983 6.88815E-08 300 END
Pd-105 2983 4.14225E-05 300 END
Cd-113 2983 7.52436E-08 300 END
Cs-133 2983 0.000383641 300 END
Cs-134 2983 1.56112E-06 300 END
La-139 2983 0.000400042 300 END
Ce-141 2983 0.000177871 300 END
Pr-141 2983 0.000190456 300 END
Pr-143 2983 9.34177E-05 300 END
Nd-143 2983 0.000299173 300 END
Nd-145 2983 0.000250104 300 END
Nd-147 2983 2.48442E-05 300 END
Pm-147 2983 0.000250104 300 END
Pm-149 2983 4.98344E-07 300 END
Sm-149 2983 7.6121E-06 300 END
Sm-150 2983 6.58689E-05 300 END
Sm-151 2983 1.18134E-05 300 END
Sm-152 2983 3.66852E-05 300 END
Eu-153 2983 1.0996E-05 300 END
Eu-154 2983 3.06101E-07 300 END
Eu-155 2983 1.48754E-06 300 END
Gd-155 2983 7.51133E-09 300 END
Gd-157 2983 2.14489E-08 300 END

' 10146   ρ= 5.219 MWD= 3.090207992
h-zrh2 10146 0.083582038 300 END
u-235 10146 0.07347924 300 END
u-238 10146 0.333774389 300 END
zr-90 10146 2.432236735 300 END
zr-91 10146 0.530463152 300 END
zr-92 10146 0.811049526 300 END
zr-94 10146 0.821882527 300 END
zr-96 10146 0.132565808 300 END
U-236 10146 0.001245663 300 END
Pu-239 10146 0.000243556 300 END
Pu-240 10146 1.06328E-05 300 END
Pu-241 10146 2.10463E-08 300 END
Np-237 10146 1.37836E-06 300 END
Kr-83 10146 1.26328E-05 300 END
I-129 10146 2.1104E-05 300 END
I-131 10146 1.83712E-05 300 END
Xe-131 10146 0.000104746 300 END
Xe-133 10146 2.57274E-05 300 END
Xe-135 10146 3.1057E-11 300 END
Mo-95 10146 1.56141E-05 300 END
Mo-97 10146 0.000183249 300 END
Tc-99 10146 0.000187047 300 END
Ru-101 10146 0.000161507 300 END
Rh-103 10146 3.58982E-05 300 END
Rh-105 10146 6.85791E-08 300 END
Pd-105 10146 2.83928E-05 300 END

Cd-113 10146 7.62642E-08 300 END
Cs-133 10146 0.000262964 300 END
Cs-134 10146 7.12054E-07 300 END
La-139 10146 0.000274207 300 END
Ce-141 10146 0.000143248 300 END
Pr-141 10146 0.000109972 300 END
Pr-143 10146 8.35445E-05 300 END
Nd-143 10146 0.000205066 300 END
Nd-145 10146 0.000171432 300 END
Nd-147 10146 2.28076E-05 300 END
Pm-147 10146 0.000171432 300 END
Pm-149 10146 4.86794E-07 300 END
Sm-149 10146 7.50683E-06 300 END
Sm-150 10146 4.44617E-05 300 END
Sm-151 10146 1.03677E-05 300 END
Sm-152 10146 2.47069E-05 300 END
Eu-153 10146 7.21675E-06 300 END
Eu-154 10146 1.33838E-07 300 END
Eu-155 10146 1.16948E-06 300 END
Gd-155 10146 5.84159E-09 300 END
Gd-157 10146 2.13471E-08 300 END

' 2980 ρ= 5.9029 MWD= 4.243225041
h-zrh2 2980 0.094563745 300 END
u-235 2980 0.08258255 300 END
u-238 2980 0.376194808 300 END
zr-90 2980 2.751794796 300 END
zr-91 2980 0.600170041 300 END
zr-92 2980 0.917667277 300 END
zr-94 2980 0.929910668 300 END
zr-96 2980 0.150028102 300 END
U-236 2980 0.001710444 300 END
Pu-239 2980 0.000324215 300 END
Pu-240 2980 1.97674E-05 300 END
Pu-241 2980 2.85814E-08 300 END
Np-237 2980 2.58497E-06 300 END
Kr-83 2980 1.73463E-05 300 END
I-129 2980 2.89783E-05 300 END
I-131 2980 1.94169E-05 300 END
Xe-131 2980 0.000143828 300 END
Xe-133 2980 2.63771E-05 300 END
Xe-135 2980 3.07837E-11 300 END
Mo-95 2980 3.10146E-05 300 END
Mo-97 2980 0.000251623 300 END
Tc-99 2980 0.000256838 300 END
Ru-101 2980 0.000221768 300 END
Rh-103 2980 5.83461E-05 300 END
Rh-105 2980 6.88507E-08 300 END
Pd-105 2980 3.89868E-05 300 END
Cd-113 2980 7.55837E-08 300 END
Cs-133 2980 0.000361081 300 END
Cs-134 2980 1.37413E-06 300 END
La-139 2980 0.000376518 300 END
Ce-141 2980 0.000172378 300 END
Pr-141 2980 0.000174509 300 END
Pr-143 2980 9.20403E-05 300 END
Nd-143 2980 0.00028158 300 END
Nd-145 2980 0.000235397 300 END
Nd-147 2980 2.45721E-05 300 END
Pm-147 2980 0.000235397 300 END
Pm-149 2980 4.96408E-07 300 END
Sm-149 2980 7.60245E-06 300 END
Sm-150 2980 6.18191E-05 300 END
Sm-151 2980 1.16132E-05 300 END
Sm-152 2980 3.44154E-05 300 END

Eu-153 2980 1.02672E-05 300 END
Eu-154 2980 2.68049E-07 300 END
Eu-155 2980 1.43299E-06 300 END
Gd-155 2980 7.22331E-09 300 END
Gd-157 2980 2.1435E-08 300 END

' 2925 ρ= 5.9774 MWD= 5.047550348
h-zrh2 2925 0.095788462 300 END
u-235 2925 0.081610586 300 END
u-238 2925 0.380990962 300 END
zr-90 2925 2.787424334 300 END
zr-91 2925 0.607952061 300 END
zr-92 2925 0.929607663 300 END
zr-94 2925 0.941996629 300 END
zr-96 2925 0.152015982 300 END
U-236 2925 0.002034668 300 END
Pu-239 2925 0.000376482 300 END
Pu-240 2925 2.77385E-05 300 END
Pu-241 2925 3.37501E-08 300 END
Np-237 2925 3.66527E-06 300 END
Kr-83 2925 2.06344E-05 300 END
I-129 2925 3.44712E-05 300 END
I-131 2925 1.98235E-05 300 END
Xe-131 2925 0.000171092 300 END
Xe-133 2925 2.65301E-05 300 END
Xe-135 2925 3.057E-11 300 END
Mo-95 2925 4.50767E-05 300 END
Mo-97 2925 0.00029932 300 END
Tc-99 2925 0.000305523 300 END
Ru-101 2925 0.000263805 300 END
Rh-103 2925 7.57102E-05 300 END
Rh-105 2925 6.89177E-08 300 END
Pd-105 2925 4.63769E-05 300 END
Cd-113 2925 7.44333E-08 300 END
Cs-133 2925 0.000429526 300 END
Cs-134 2925 1.98416E-06 300 END
La-139 2925 0.000447889 300 END
Ce-141 2925 0.000187885 300 END
Pr-141 2925 0.000223993 300 END
Pr-143 2925 9.57393E-05 300 END
Nd-143 2925 0.000334955 300 END
Nd-145 2925 0.000280018 300 END
Nd-147 2925 2.52903E-05 300 END
Pm-147 2925 0.000280018 300 END
Pm-149 2925 5.02095E-07 300 END
Sm-149 2925 7.62284E-06 300 END
Sm-150 2925 7.41743E-05 300 END
Sm-151 2925 1.21463E-05 300 END
Sm-152 2925 4.13456E-05 300 END
Eu-153 2925 1.25103E-05 300 END
Eu-154 2925 3.92046E-07 300 END
Eu-155 2925 1.59324E-06 300 END
Gd-155 2925 8.07082E-09 300 END
Gd-157 2925 2.14728E-08 300 END

' 2941 ρ= 5.9811 MWD= 4.887694597
h-zrh2 2941 0.095840577 300 END
u-235 2941 0.082097964 300 END
u-238 2941 0.38121482 300 END
zr-90 2941 2.788942985 300 END
zr-91 2941 0.608280848 300 END
zr-92 2941 0.930101379 300 END
zr-94 2941 0.942499924 300 END
zr-96 2941 0.152088961 300 END
U-236 2941 0.00197023 300 END

Pu-239 2941 0.000366354 300 END
Pu-240 2941 2.60505E-05 300 END
Pu-241 2941 3.27285E-08 300 END
Np-237 2941 3.43444E-06 300 END
Kr-83 2941 1.99809E-05 300 END
I-129 2941 3.33795E-05 300 END
I-131 2941 1.97573E-05 300 END
Xe-131 2941 0.000165673 300 END
Xe-133 2941 2.65126E-05 300 END
Xe-135 2941 3.06135E-11 300 END
Mo-95 2941 4.20631E-05 300 END
Mo-97 2941 0.00028984 300 END
Tc-99 2941 0.000295847 300 END
Ru-101 2941 0.00025545 300 END
Rh-103 2941 7.21642E-05 300 END
Rh-105 2941 6.89103E-08 300 END
Pd-105 2941 4.49081E-05 300 END
Cd-113 2941 7.46873E-08 300 END
Cs-133 2941 0.000415923 300 END
Cs-134 2941 1.85266E-06 300 END
La-139 2941 0.000433705 300 END
Ce-141 2941 0.000185069 300 END
Pr-141 2941 0.000213904 300 END
Pr-143 2941 9.51118E-05 300 END
Nd-143 2941 0.000324347 300 END
Nd-145 2941 0.00027115 300 END
Nd-147 2941 2.51715E-05 300 END
Pm-147 2941 0.00027115 300 END
Pm-149 2941 5.01005E-07 300 END
Sm-149 2941 7.62074E-06 300 END
Sm-150 2941 7.17026E-05 300 END
Sm-151 2941 1.20571E-05 300 END
Sm-152 2941 3.99579E-05 300 END
Eu-153 2941 1.20569E-05 300 END
Eu-154 2941 3.65361E-07 300 END
Eu-155 2941 1.56258E-06 300 END
Gd-155 2941 7.90834E-09 300 END
Gd-157 2941 2.14662E-08 300 END

' 2979 ρ= 6.003 MWD= 4.59312711
h-zrh2 2979 0.096179329 300 END
u-235 2979 0.083237696 300 END
u-238 2979 0.382593545 300 END
zr-90 2979 2.798804486 300 END
zr-91 2979 0.610427368 300 END
zr-92 2979 0.93336585 300 END
zr-94 2979 0.945813541 300 END
zr-96 2979 0.152607868 300 END
U-236 2979 0.00185149 300 END
Pu-239 2979 0.000347355 300 END
Pu-240 2979 2.30747E-05 300 END
Pu-241 2979 3.08386E-08 300 END
Np-237 2979 3.03017E-06 300 END
Kr-83 2979 1.87767E-05 300 END
I-129 2979 3.13678E-05 300 END
I-131 2979 1.96175E-05 300 END
Xe-131 2979 0.000155689 300 END
Xe-133 2979 2.64648E-05 300 END
Xe-135 2979 3.06925E-11 300 END
Mo-95 2979 3.67944E-05 300 END
Mo-97 2979 0.000272372 300 END
Tc-99 2979 0.000278017 300 END
Ru-101 2979 0.000240055 300 END
Rh-103 2979 6.57496E-05 300 END
Rh-105 2979 6.88894E-08 300 END

Pd-105 2979 4.22017E-05 300 END
Cd-113 2979 7.51257E-08 300 END
Cs-133 2979 0.000390857 300 END
Cs-134 2979 1.62382E-06 300 END
La-139 2979 0.000407567 300 END
Ce-141 2979 0.000179546 300 END
Pr-141 2979 0.000195634 300 END
Pr-143 2979 9.38232E-05 300 END
Nd-143 2979 0.0003048 300 END
Nd-145 2979 0.000254808 300 END
Nd-147 2979 2.49233E-05 300 END
Pm-147 2979 0.000254808 300 END
Pm-149 2979 4.98949E-07 300 END
Sm-149 2979 7.61452E-06 300 END
Sm-150 2979 6.7169E-05 300 END
Sm-151 2979 1.18721E-05 300 END
Sm-152 2979 3.74143E-05 300 END
Eu-153 2979 1.12314E-05 300 END
Eu-154 2979 3.18854E-07 300 END
Eu-155 2979 1.50461E-06 300 END
Gd-155 2979 7.60155E-09 300 END
Gd-157 2979 2.1453E-08 300 END

' 2964 ρ= 6.0532 MWD= 4.733310251
h-zrh2 2964 0.09698712 300 END
u-235 2964 0.083659987 300 END
u-238 2964 0.385796205 300 END
zr-90 2964 2.822309714 300 END
zr-91 2964 0.615555771 300 END
zr-92 2964 0.941212622 300 END
zr-94 2964 0.953763007 300 END
zr-96 2964 0.15389567 300 END
U-236 2964 0.001907997 300 END
Pu-239 2964 0.000356451 300 END
Pu-240 2964 2.44691E-05 300 END
Pu-241 2964 3.17392E-08 300 END
Np-237 2964 3.21917E-06 300 END
Kr-83 2964 1.93498E-05 300 END
I-129 2964 3.23252E-05 300 END
I-131 2964 1.96871E-05 300 END
Xe-131 2964 0.00016044 300 END
Xe-133 2964 2.64902E-05 300 END
Xe-135 2964 3.06551E-11 300 END
Mo-95 2964 3.92558E-05 300 END
Mo-97 2964 0.000280685 300 END
Tc-99 2964 0.000286503 300 END
Ru-101 2964 0.000247382 300 END
Rh-103 2964 6.87824E-05 300 END
Rh-105 2964 6.89006E-08 300 END
Pd-105 2964 4.34897E-05 300 END
Cd-113 2964 7.49223E-08 300 END
Cs-133 2964 0.000402786 300 END
Cs-134 2964 1.73056E-06 300 END
La-139 2964 0.000420006 300 END
Ce-141 2964 0.00018223 300 END
Pr-141 2964 0.000204275 300 END
Pr-143 2964 9.44588E-05 300 END
Nd-143 2964 0.000314102 300 END
Nd-145 2964 0.000262585 300 END
Nd-147 2964 2.50464E-05 300 END
Pm-147 2964 0.000262585 300 END
Pm-149 2964 4.99936E-07 300 END
Sm-149 2964 7.61789E-06 300 END
Sm-150 2964 6.93231E-05 300 END
Sm-151 2964 1.19636E-05 300 END

Sm-152 2964 3.86226E-05 300 END
Eu-153 2964 1.16227E-05 300 END
Eu-154 2964 3.40557E-07 300 END
Eu-155 2964 1.53245E-06 300 END
Gd-155 2964 7.74879E-09 300 END
Gd-157 2964 2.14595E-08 300 END

' 2910   ρ= 6.0618 MWD= 4.546455989
h-zrh2 2910 0.097117409 300 END
u-235 2910 0.084298743 300 END
u-238 2910 0.386333824 300 END
zr-90 2910 2.826103506 300 END
zr-91 2910 0.616380557 300 END
zr-92 2910 0.942462774 300 END
zr-94 2910 0.955033305 300 END
zr-96 2910 0.154090849 300 END
U-236 2910 0.001832676 300 END
Pu-239 2910 0.000344304 300 END
Pu-240 2910 2.26193E-05 300 END
Pu-241 2910 3.05383E-08 300 END
Np-237 2910 2.96861E-06 300 END
Kr-83 2910 1.85859E-05 300 END
I-129 2910 3.10491E-05 300 END
I-131 2910 1.95931E-05 300 END
Xe-131 2910 0.000154107 300 END
Xe-133 2910 2.64552E-05 300 END
Xe-135 2910 3.07048E-11 300 END
Mo-95 2910 3.59935E-05 300 END
Mo-97 2910 0.000269605 300 END
Tc-99 2910 0.000275192 300 END
Ru-101 2910 0.000237616 300 END
Rh-103 2910 6.47481E-05 300 END
Rh-105 2910 6.88852E-08 300 END
Pd-105 2910 4.17728E-05 300 END
Cd-113 2910 7.51911E-08 300 END
Cs-133 2910 0.000386885 300 END
Cs-134 2910 1.58914E-06 300 END
La-139 2910 0.000403425 300 END
Ce-141 2910 0.000178629 300 END
Pr-141 2910 0.00019278 300 END
Pr-143 2910 9.3602E-05 300 END
Nd-143 2910 0.000301703 300 END
Nd-145 2910 0.000252219 300 END
Nd-147 2910 2.48802E-05 300 END
Pm-147 2910 0.000252219 300 END
Pm-149 2910 4.98617E-07 300 END
Sm-149 2910 7.61323E-06 300 END
Sm-150 2910 6.64532E-05 300 END
Sm-151 2910 1.18401E-05 300 END
Sm-152 2910 3.70129E-05 300 END
Eu-153 2910 1.11017E-05 300 END
Eu-154 2910 3.118E-07 300 END
Eu-155 2910 1.49524E-06 300 END
Gd-155 2910 7.552E-09 300 END
Gd-157 2910 2.14508E-08 300 END

' 2959   ρ= 6.0797 MWD= 4.582852321
h-zrh2 2959 0.097404045 300 END
u-235 2959 0.084484947 300 END
u-238 2959 0.387471612 300 END
zr-90 2959 2.834444243 300 END
zr-91 2959 0.618200149 300 END
zr-92 2959 0.945246123 300 END
zr-94 2959 0.957853327 300 END
zr-96 2959 0.154547013 300 END

U-236 2959 0.001847348 300 END
Pu-239 2959 0.000346684 300 END
Pu-240 2959 2.29741E-05 300 END
Pu-241 2959 3.07725E-08 300 END
Np-237 2959 3.01656E-06 300 END
Kr-83 2959 1.87347E-05 300 END
I-129 2959 3.12977E-05 300 END
I-131 2959 1.96122E-05 300 END
Xe-131 2959 0.00015534 300 END
Xe-133 2959 2.64628E-05 300 END
Xe-135 2959 3.06952E-11 300 END
Mo-95 2959 3.66173E-05 300 END
Mo-97 2959 0.000271763 300 END
Tc-99 2959 0.000277395 300 END
Ru-101 2959 0.000239518 300 END
Rh-103 2959 6.55287E-05 300 END
Rh-105 2959 6.88885E-08 300 END
Pd-105 2959 4.21072E-05 300 END
Cd-113 2959 7.51402E-08 300 END
Cs-133 2959 0.000389982 300 END
Cs-134 2959 1.61615E-06 300 END
La-139 2959 0.000406655 300 END
Ce-141 2959 0.000179345 300 END
Pr-141 2959 0.000195005 300 END
Pr-143 2959 9.37749E-05 300 END
Nd-143 2959 0.000304118 300 END
Nd-145 2959 0.000254238 300 END
Nd-147 2959 2.49139E-05 300 END
Pm-147 2959 0.000254238 300 END
Pm-149 2959 4.98876E-07 300 END
Sm-149 2959 7.61425E-06 300 END
Sm-150 2959 6.70113E-05 300 END
Sm-151 2959 1.18651E-05 300 END
Sm-152 2959 3.73259E-05 300 END
Eu-153 2959 1.12028E-05 300 END
Eu-154 2959 3.17293E-07 300 END
Eu-155 2959 1.50255E-06 300 END
Gd-155 2959 7.59066E-09 300 END
Gd-157 2959 2.14525E-08 300 END

' 2906   ρ= 6.1344 MWD= 4.825224838
h-zrh2 2906 0.09829001 300 END
u-235 2906 0.084706669 300 END
u-238 2906 0.390975239 300 END
zr-90 2906 2.860223044 300 END
zr-91 2906 0.62382589 300 END
zr-92 2906 0.953858815 300 END
zr-94 2906 0.966577119 300 END
zr-96 2906 0.155964744 300 END
U-236 2906 0.001945048 300 END
Pu-239 2906 0.000362362 300 END
Pu-240 2906 2.54049E-05 300 END
Pu-241 2906 3.23285E-08 300 END
Np-237 2906 3.34643E-06 300 END
Kr-83 2906 1.97255E-05 300 END
I-129 2906 3.29529E-05 300 END
I-131 2906 1.97296E-05 300 END
Xe-131 2906 0.000163556 300 END
Xe-133 2906 2.65042E-05 300 END
Xe-135 2906 3.06304E-11 300 END
Mo-95 2906 4.0915E-05 300 END
Mo-97 2906 0.000286136 300 END
Tc-99 2906 0.000292066 300 END
Ru-101 2906 0.000252186 300 END
Rh-103 2906 7.07906E-05 300 END

Rh-105 2906 6.89067E-08 300 END
Pd-105 2906 4.43342E-05 300 END
Cd-113 2906 7.47837E-08 300 END
Cs-133 2906 0.000410607 300 END
Cs-134 2906 1.80268E-06 300 END
La-139 2906 0.000428162 300 END
Ce-141 2906 0.000183935 300 END
Pr-141 2906 0.000209994 300 END
Pr-143 2906 9.48533E-05 300 END
Nd-143 2906 0.000320202 300 END
Nd-145 2906 0.000267684 300 END
Nd-147 2906 2.51222E-05 300 END
Pm-147 2906 0.000267684 300 END
Pm-149 2906 5.00575E-07 300 END
Sm-149 2906 7.61969E-06 300 END
Sm-150 2906 7.07389E-05 300 END
Sm-151 2906 1.20202E-05 300 END
Sm-152 2906 3.9417E-05 300 END
Eu-153 2906 1.18808E-05 300 END
Eu-154 2906 3.55211E-07 300 END
Eu-155 2906 1.55045E-06 300 END
Gd-155 2906 7.8441E-09 300 END
Gd-157 2906 2.14636E-08 300 END

' 2992   ρ= 6.309 MWD= 5.87277543
h-zrh2 2992 0.101127855 300 END
u-235 2992 0.082579194 300 END
u-238 2992 0.404087544 300 END
zr-90 2992 2.942791113 300 END
zr-91 2992 0.641850925 300 END
zr-92 2992 0.98146708 300 END
zr-94 2992 0.994535767 300 END
zr-96 2992 0.160522118 300 END
U-236 2992 0.002367316 300 END
Pu-239 2992 0.000426736 300 END
Pu-240 2992 3.72652E-05 300 END
Pu-241 2992 3.89806E-08 300 END
Np-237 2992 4.98812E-06 300 END
Kr-83 2992 2.40079E-05 300 END
I-129 2992 4.01069E-05 300 END
I-131 2992 2.0078E-05 300 END
Xe-131 2992 0.000199064 300 END
Xe-133 2992 2.65457E-05 300 END
Xe-135 2992 3.03387E-11 300 END
Mo-95 2992 6.23611E-05 300 END
Mo-97 2992 0.000348256 300 END
Tc-99 2992 0.000355473 300 END
Ru-101 2992 0.000306935 300 END
Rh-103 2992 9.46658E-05 300 END
Rh-105 2992 6.89177E-08 300 END
Pd-105 2992 5.39591E-05 300 END
Cd-113 2992 7.29952E-08 300 END
Cs-133 2992 0.00049975 300 END
Cs-134 2992 2.7484E-06 300 END
La-139 2992 0.000521115 300 END
Ce-141 2992 0.000200613 300 END
Pr-141 2992 0.000277869 300 END
Pr-143 2992 9.83081E-05 300 END
Nd-143 2992 0.000389717 300 END
Nd-145 2992 0.000325798 300 END
Nd-147 2992 2.57582E-05 300 END
Pm-147 2992 0.000325798 300 END
Pm-149 2992 5.07495E-07 300 END
Sm-149 2992 7.62247E-06 300 END
Sm-150 2992 8.70616E-05 300 END

Sm-151 2992 1.25006E-05 300 END
Sm-152 2992 4.85904E-05 300 END
Eu-153 2992 1.49099E-05 300 END
Eu-154 2992 5.4624E-07 300 END
Eu-155 2992 1.744E-06 300 END
Gd-155 2992 8.87151E-09 300 END
Gd-157 2992 2.15008E-08 300 END

' 2962 ρ= 6.1217 MWD= 4.716411147
h-zrh2 2962 0.098081548 300 END
u-235 2962 0.084795576 300 END
u-238 2962 0.390156114 300 END
zr-90 2962 2.854158106 300 END
zr-91 2962 0.622501567 300 END
zr-92 2962 0.951828465 300 END
zr-94 2962 0.964521527 300 END
zr-96 2962 0.155628062 300 END
U-236 2962 0.001901185 300 END
Pu-239 2962 0.00035536 300 END
Pu-240 2962 2.42989E-05 300 END
Pu-241 2962 3.16307E-08 300 END
Np-237 2962 3.19606E-06 300 END
Kr-83 2962 1.92807E-05 300 END
I-129 2962 3.22098E-05 300 END
I-131 2962 1.9679E-05 300 END
Xe-131 2962 0.000159867 300 END
Xe-133 2962 2.64875E-05 300 END
Xe-135 2962 3.06596E-11 300 END
Mo-95 2962 3.89546E-05 300 END
Mo-97 2962 0.000279683 300 END
Tc-99 2962 0.00028548 300 END
Ru-101 2962 0.000246499 300 END
Rh-103 2962 6.84148E-05 300 END
Rh-105 2962 6.88994E-08 300 END
Pd-105 2962 4.33344E-05 300 END
Cd-113 2962 7.49473E-08 300 END
Cs-133 2962 0.000401348 300 END
Cs-134 2962 1.71749E-06 300 END
La-139 2962 0.000418506 300 END
Ce-141 2962 0.000181912 300 END
Pr-141 2962 0.000203228 300 END
Pr-143 2962 9.43844E-05 300 END
Nd-143 2962 0.000312981 300 END
Nd-145 2962 0.000261648 300 END
Nd-147 2962 2.50321E-05 300 END
Pm-147 2962 0.000261648 300 END
Pm-149 2962 4.99818E-07 300 END
Sm-149 2962 7.61752E-06 300 END
Sm-150 2962 6.90631E-05 300 END
Sm-151 2962 1.19529E-05 300 END
Sm-152 2962 3.84767E-05 300 END
Eu-153 2962 1.15753E-05 300 END
Eu-154 2962 3.379E-07 300 END
Eu-155 2962 1.52912E-06 300 END
Gd-155 2962 7.73116E-09 300 END
Gd-157 2962 2.14587E-08 300 END

' 10147 ρ= 5.2294 MWD= 2.92347418
h-zrh2 10147 0.083740889 300 END
u-235 10147 0.074089123 300 END
u-238 10147 0.334424681 300 END
zr-90 10147 2.436861088 300 END
zr-91 10147 0.531470345 300 END
zr-92 10147 0.812578576 300 END
zr-94 10147 0.823434762 300 END

zr-96 10147 0.132807428 300 END
U-236 10147 0.001178452 300 END
Pu-239 10147 0.000231336 300 END
Pu-240 10147 9.53797E-06 300 END
Pu-241 10147 1.9944E-08 300 END
Np-237 10147 1.23602E-06 300 END
Kr-83 10147 1.19512E-05 300 END
I-129 10147 1.99653E-05 300 END
I-131 10147 1.81503E-05 300 END
Xe-131 10147 9.90941E-05 300 END
Xe-133 10147 2.5565E-05 300 END
Xe-135 10147 3.10917E-11 300 END
Mo-95 10147 1.38438E-05 300 END
Mo-97 10147 0.000173362 300 END
Tc-99 10147 0.000176955 300 END
Ru-101 10147 0.000152792 300 END
Rh-103 10147 3.29385E-05 300 END
Rh-105 10147 6.85153E-08 300 END
Pd-105 10147 2.68609E-05 300 END
Cd-113 10147 7.61921E-08 300 END
Cs-133 10147 0.000248776 300 END
Cs-134 10147 6.35661E-07 300 END
La-139 10147 0.000259412 300 END
Ce-141 10147 0.000138221 300 END
Pr-141 10147 0.000101374 300 END
Pr-143 10147 8.18723E-05 300 END
Nd-143 10147 0.000194002 300 END
Nd-145 10147 0.000162183 300 END
Nd-147 10147 2.2446E-05 300 END
Pm-147 10147 0.000162183 300 END
Pm-149 10147 4.85154E-07 300 END
Sm-149 10147 7.48214E-06 300 END
Sm-150 10147 4.19863E-05 300 END
Sm-151 10147 1.01237E-05 300 END
Sm-152 10147 2.3325E-05 300 END
Eu-153 10147 6.79172E-06 300 END
Eu-154 10147 1.18526E-07 300 END
Eu-155 10147 1.12694E-06 300 END
Gd-155 10147 5.62032E-09 300 END
Gd-157 10147 2.13287E-08 300 END

' 2928 ρ= 6.1285 MWD= 4.598885136
h-zrh2 2928 0.098185779 300 END
u-235 2928 0.085219519 300 END
u-238 2928 0.390583006 300 END
zr-90 2928 2.857192743 300 END
zr-91 2928 0.623161751 300 END
zr-92 2928 0.952830942 300 END
zr-94 2928 0.965539577 300 END
zr-96 2928 0.155786117 300 END
U-236 2928 0.001853811 300 END
Pu-239 2928 0.00034773 300 END
Pu-240 2928 2.31312E-05 300 END
Pu-241 2928 3.08757E-08 300 END
Np-237 2928 3.03782E-06 300 END
Kr-83 2928 1.88002E-05 300 END
I-129 2928 3.14072E-05 300 END
I-131 2928 1.96205E-05 300 END
Xe-131 2928 0.000155884 300 END
Xe-133 2928 2.6466E-05 300 END
Xe-135 2928 3.06909E-11 300 END
Mo-95 2928 3.68939E-05 300 END
Mo-97 2928 0.000272714 300 END
Tc-99 2928 0.000278366 300 END
Ru-101 2928 0.000240356 300 END

Rh-103 2928 6.58734E-05 300 END
Rh-105 2928 6.88899E-08 300 END
Pd-105 2928 4.22546E-05 300 END
Cd-113 2928 7.51175E-08 300 END
Cs-133 2928 0.000391347 300 END
Cs-134 2928 1.62813E-06 300 END
La-139 2928 0.000408077 300 END
Ce-141 2928 0.000179658 300 END
Pr-141 2928 0.000195987 300 END
Pr-143 2928 9.38501E-05 300 END
Nd-143 2928 0.000305182 300 END
Nd-145 2928 0.000255128 300 END
Nd-147 2928 2.49286E-05 300 END
Pm-147 2928 0.000255128 300 END
Pm-149 2928 4.9899E-07 300 END
Sm-149 2928 7.61468E-06 300 END
Sm-150 2928 6.72573E-05 300 END
Sm-151 2928 1.1876E-05 300 END
Sm-152 2928 3.74638E-05 300 END
Eu-153 2928 1.12474E-05 300 END
Eu-154 2928 3.1973E-07 300 END
Eu-155 2928 1.50576E-06 300 END
Gd-155 2928 7.60764E-09 300 END
Gd-157 2928 2.14533E-08 300 END

' 2939 ρ= 6.0835 MWD= 4.376508249
h-zrh2 2939 0.097456161 300 END
u-235 2939 0.085098973 300 END
u-238 2939 0.387699729 300 END
zr-90 2939 2.835963368 300 END
zr-91 2939 0.618528677 300 END
zr-92 2939 0.945736514 300 END
zr-94 2939 0.958353987 300 END
zr-96 2939 0.154617211 300 END
U-236 2939 0.00176417 300 END
Pu-239 2939 0.000333103 300 END
Pu-240 2939 2.0998E-05 300 END
Pu-241 2939 2.94428E-08 300 END
Np-237 2939 2.75012E-06 300 END
Kr-83 2939 1.78912E-05 300 END
I-129 2939 2.98885E-05 300 END
I-131 2939 1.94982E-05 300 END
Xe-131 2939 0.000148346 300 END
Xe-133 2939 2.64149E-05 300 END
Xe-135 2939 3.07493E-11 300 END
Mo-95 2939 3.3155E-05 300 END
Mo-97 2939 0.000259527 300 END
Tc-99 2939 0.000264906 300 END
Ru-101 2939 0.000228734 300 END
Rh-103 2939 6.11373E-05 300 END
Rh-105 2939 6.88673E-08 300 END
Pd-105 2939 4.02114E-05 300 END
Cd-113 2939 7.54184E-08 300 END
Cs-133 2939 0.000372423 300 END
Cs-134 2939 1.46645E-06 300 END
La-139 2939 0.000388345 300 END
Ce-141 2939 0.00017519 300 END
Pr-141 2939 0.00018248 300 END
Pr-143 2939 9.27543E-05 300 END
Nd-143 2939 0.000290425 300 END
Nd-145 2939 0.000242791 300 END
Nd-147 2939 2.47137E-05 300 END
Pm-147 2939 0.000242791 300 END
Pm-149 2939 4.9739E-07 300 END
Sm-149 2939 7.60772E-06 300 END

Sm-150 2939 6.38524E-05 300 END
Sm-151 2939 1.17172E-05 300 END
Sm-152 2939 3.55548E-05 300 END
Eu-153 2939 1.06324E-05 300 END
Eu-154 2939 2.86837E-07 300 END
Eu-155 2939 1.46065E-06 300 END
Gd-155 2939 7.36928E-09 300 END
Gd-157 2939 2.14422E-08 300 END

' 5918   ρ= 6.2765 MWD= 5.80554554
h-zrh2 5918 0.100605558 300 END
u-235 5918 0.082762348 300 END
u-238 5918 0.401539044 300 END
zr-90 5918 2.927593051 300 END
zr-91 5918 0.638535067 300 END
zr-92 5918 0.976395192 300 END
zr-94 5918 0.989397176 300 END
zr-96 5918 0.159690859 300 END
U-236 5918 0.002340215 300 END
Pu-239 5918 0.000422768 300 END
Pu-240 5918 3.64383E-05 300 END
Pu-241 5918 3.85572E-08 300 END
Np-237 5918 4.87198E-06 300 END
Kr-83 5918 2.37331E-05 300 END
I-129 5918 3.96478E-05 300 END
I-131 5918 2.0062E-05 300 END
Xe-131 5918 0.000196785 300 END
Xe-133 5918 2.65484E-05 300 END
Xe-135 5918 3.03579E-11 300 END
Mo-95 5918 6.08449E-05 300 END
Mo-97 5918 0.000344269 300 END
Tc-99 5918 0.000351404 300 END
Ru-101 5918 0.000303421 300 END
Rh-103 5918 9.3084E-05 300 END
Rh-105 5918 6.89198E-08 300 END
Pd-105 5918 5.33414E-05 300 END
Cd-113 5918 7.31184E-08 300 END
Cs-133 5918 0.000494029 300 END
Cs-134 5918 2.68063E-06 300 END
La-139 5918 0.000515149 300 END
Ce-141 5918 0.00019968 300 END
Pr-141 5918 0.000273374 300 END
Pr-143 5918 9.81357E-05 300 END
Nd-143 5918 0.000385256 300 END
Nd-145 5918 0.000322068 300 END
Nd-147 5918 2.5728E-05 300 END
Pm-147 5918 0.000322068 300 END
Pm-149 5918 5.07067E-07 300 END
Sm-149 5918 7.62309E-06 300 END
Sm-150 5918 8.60037E-05 300 END
Sm-151 5918 1.24776E-05 300 END
Sm-152 5918 4.79951E-05 300 END
Eu-153 5918 1.47107E-05 300 END
Eu-154 5918 5.32636E-07 300 END
Eu-155 5918 1.73214E-06 300 END
Gd-155 5918 8.80839E-09 300 END
Gd-157 5918 2.14988E-08 300 END

' 2977   ρ= 6.152 MWD= 4.33553765
h-zrh2 2977 0.098550588 300 END
u-235 2977 0.08630014 300 END
u-238 2977 0.392061994 300 END
zr-90 2977 2.867812046 300 END
zr-91 2977 0.625474242 300 END
zr-92 2977 0.956350597 300 END

zr-94 2977 0.969111143 300 END
zr-96 2977 0.156348163 300 END
U-236 2977 0.001747655 300 END
Pu-239 2977 0.00033038 300 END
Pu-240 2977 2.06159E-05 300 END
Pu-241 2977 2.91783E-08 300 END
Np-237 2977 2.69877E-06 300 END
Kr-83 2977 1.77237E-05 300 END
I-129 2977 2.96087E-05 300 END
I-131 2977 1.94738E-05 300 END
Xe-131 2977 0.000146957 300 END
Xe-133 2977 2.64039E-05 300 END
Xe-135 2977 3.07599E-11 300 END
Mo-95 2977 3.2489E-05 300 END
Mo-97 2977 0.000257097 300 END
Tc-99 2977 0.000262426 300 END
Ru-101 2977 0.000226593 300 END
Rh-103 2977 6.02754E-05 300 END
Rh-105 2977 6.88625E-08 300 END
Pd-105 2977 3.98349E-05 300 END
Cd-113 2977 7.54705E-08 300 END
Cs-133 2977 0.000368937 300 END
Cs-134 2977 1.43771E-06 300 END
La-139 2977 0.00038471 300 END
Ce-141 2977 0.000174336 300 END
Pr-141 2977 0.000180019 300 END
Pr-143 2977 9.25396E-05 300 END
Nd-143 2977 0.000287706 300 END
Nd-145 2977 0.000240518 300 END
Nd-147 2977 2.46713E-05 300 END
Pm-147 2977 0.000240518 300 END
Pm-149 2977 4.9709E-07 300 END
Sm-149 2977 7.60619E-06 300 END
Sm-150 2977 6.32268E-05 300 END
Sm-151 2977 1.16859E-05 300 END
Sm-152 2977 3.52042E-05 300 END
Eu-153 2977 1.05198E-05 300 END
Eu-154 2977 2.80988E-07 300 END
Eu-155 2977 1.4522E-06 300 END
Gd-155 2977 7.32467E-09 300 END
Gd-157 2977 2.144E-08 300 END

' 2974 ρ= 6.1876 MWD= 4.444307851
h-zrh2 2974 0.09912386 300 END
u-235 2974 0.086574535 300 END
u-238 2974 0.39433406 300 END
zr-90 2974 2.884493097 300 END
zr-91 2974 0.629113765 300 END
zr-92 2974 0.961919923 300 END
zr-94 2974 0.974753225 300 END
zr-96 2974 0.157262643 300 END
U-236 2974 0.0017915 300 END
Pu-239 2974 0.000337589 300 END
Pu-240 2974 2.16378E-05 300 END
Pu-241 2974 2.98803E-08 300 END
Np-237 2974 2.83621E-06 300 END
Kr-83 2974 1.81683E-05 300 END
I-129 2974 3.03515E-05 300 END
I-131 2974 1.95372E-05 300 END
Xe-131 2974 0.000150644 300 END
Xe-133 2974 2.6432E-05 300 END
Xe-135 2974 3.07316E-11 300 END
Mo-95 2974 3.42727E-05 300 END
Mo-97 2974 0.000263547 300 END
Tc-99 2974 0.00026901 300 END

Ru-101 2974 0.000232277 300 END
Rh-103 2974 6.25709E-05 300 END
Rh-105 2974 6.88749E-08 300 END
Pd-105 2974 4.08343E-05 300 END
Cd-113 2974 7.53299E-08 300 END
Cs-133 2974 0.000378193 300 END
Cs-134 2974 1.51473E-06 300 END
La-139 2974 0.000394361 300 END
Ce-141 2974 0.000176581 300 END
Pr-141 2974 0.000186571 300 END
Pr-143 2974 9.31007E-05 300 END
Nd-143 2974 0.000294924 300 END
Nd-145 2974 0.000246552 300 END
Nd-147 2974 2.4782E-05 300 END
Pm-147 2974 0.000246552 300 END
Pm-149 2974 4.97883E-07 300 END
Sm-149 2974 7.61007E-06 300 END
Sm-150 2974 6.48889E-05 300 END
Sm-151 2974 1.17675E-05 300 END
Sm-152 2974 3.61358E-05 300 END
Eu-153 2974 1.08191E-05 300 END
Eu-154 2974 2.9666E-07 300 END
Eu-155 2974 1.47454E-06 300 END
Gd-155 2974 7.44262E-09 300 END
Gd-157 2974 2.14457E-08 300 END

' 2905   ρ= 6.2042 MWD= 4.926701649
h-zrh2 2905 0.099410495 300 END
u-235 2905 0.085545708 300 END
u-238 2905 0.395426891 300 END
zr-90 2905 2.89282821 300 END
zr-91 2905 0.630938488 300 END
zr-92 2905 0.964736211 300 END
zr-94 2905 0.977598528 300 END
zr-96 2905 0.157745489 300 END
U-236 2905 0.001985953 300 END
Pu-239 2905 0.000368837 300 END
Pu-240 2905 2.64577E-05 300 END
Pu-241 2905 3.2978E-08 300 END
Np-237 2905 3.49002E-06 300 END
Kr-83 2905 2.01404E-05 300 END
I-129 2905 3.36459E-05 300 END
I-131 2905 1.9774E-05 300 END
Xe-131 2905 0.000166995 300 END
Xe-133 2905 2.65174E-05 300 END
Xe-135 2905 3.06029E-11 300 END
Mo-95 2905 4.27885E-05 300 END
Mo-97 2905 0.000292153 300 END
Tc-99 2905 0.000298208 300 END
Ru-101 2905 0.000257489 300 END
Rh-103 2905 7.30254E-05 300 END
Rh-105 2905 6.89124E-08 300 END
Pd-105 2905 4.52665E-05 300 END
Cd-113 2905 7.46263E-08 300 END
Cs-133 2905 0.000419243 300 END
Cs-134 2905 1.88427E-06 300 END
La-139 2905 0.000437166 300 END
Ce-141 2905 0.000185768 300 END
Pr-141 2905 0.000216354 300 END
Pr-143 2905 9.52693E-05 300 END
Nd-143 2905 0.000326936 300 END
Nd-145 2905 0.000273314 300 END
Nd-147 2905 2.52015E-05 300 END
Pm-147 2905 0.000273314 300 END
Pm-149 2905 5.01273E-07 300 END

Sm-149 2905 7.62133E-06 300 END
Sm-150 2905 7.2305E-05 300 END
Sm-151 2905 1.20796E-05 300 END
Sm-152 2905 4.0296E-05 300 END
Eu-153 2905 1.21672E-05 300 END
Eu-154 2905 3.71778E-07 300 END
Eu-155 2905 1.57011E-06 300 END
Gd-155 2905 7.94823E-09 300 END
Gd-157 2905 2.14679E-08 300 END

' 2943   ρ= 6.1477 MWD= 4.134299951
h-zrh2 2943 0.098472415 300 END
u-235 2943 0.086770547 300 END
u-238 2943 0.391770529 300 END
zr-90 2943 2.865539595 300 END
zr-91 2943 0.624976079 300 END
zr-92 2943 0.955577484 300 END
zr-94 2943 0.968331201 300 END
zr-96 2943 0.156212309 300 END
U-236 2943 0.001666536 300 END
Pu-239 2943 0.000316885 300 END
Pu-240 2943 1.87884E-05 300 END
Pu-241 2943 2.7876E-08 300 END
Np-237 2943 2.45402E-06 300 END
Kr-83 2943 1.6901E-05 300 END
I-129 2943 2.82344E-05 300 END
I-131 2943 1.93456E-05 300 END
Xe-131 2943 0.000140136 300 END
Xe-133 2943 2.63418E-05 300 END
Xe-135 2943 3.08114E-11 300 END
Mo-95 2943 2.93211E-05 300 END
Mo-97 2943 0.000245164 300 END
Tc-99 2943 0.000250245 300 END
Ru-101 2943 0.000216075 300 END
Rh-103 2943 5.60925E-05 300 END
Rh-105 2943 6.88351E-08 300 END
Pd-105 2943 3.79859E-05 300 END
Cd-113 2943 7.57091E-08 300 END
Cs-133 2943 0.000351812 300 END
Cs-134 2943 1.3012E-06 300 END
La-139 2943 0.000366853 300 END
Ce-141 2943 0.000170003 300 END
Pr-141 2943 0.000168068 300 END
Pr-143 2943 9.14225E-05 300 END
Nd-143 2943 0.000274352 300 END
Nd-145 2943 0.000229354 300 END
Nd-147 2943 2.44485E-05 300 END
Pm-147 2943 0.000229354 300 END
Pm-149 2943 4.9559E-07 300 END
Sm-149 2943 7.59747E-06 300 END
Sm-150 2943 6.01615E-05 300 END
Sm-151 2943 1.1523E-05 300 END
Sm-152 2943 3.34869E-05 300 END
Eu-153 2943 9.97071E-06 300 END
Eu-154 2943 2.53207E-07 300 END
Eu-155 2943 1.41002E-06 300 END
Gd-155 2943 7.10219E-09 300 END
Gd-157 2943 2.14288E-08 300 END

' 10148   ρ= 5.3337 MWD= 2.91344003
h-zrh2 10148 0.085408823 300 END
u-235 10148 0.075750785 300 END
u-238 10148 0.341091565 300 END
zr-90 10148 2.485398595 300 END
zr-91 10148 0.542056151 300 END

zr-92 10148 0.828758564 300 END
zr-94 10148 0.839831901 300 END
zr-96 10148 0.135448575 300 END
U-236 10148 0.001174408 300 END
Pu-239 10148 0.000230596 300 END
Pu-240 10148 9.47392E-06 300 END
Pu-241 10148 1.98776E-08 300 END
Np-237 10148 1.22771E-06 300 END
Kr-83 10148 1.19101E-05 300 END
I-129 10148 1.98968E-05 300 END
I-131 10148 1.81362E-05 300 END
Xe-131 10148 9.8754E-05 300 END
Xe-133 10148 2.55544E-05 300 END
Xe-135 10148 3.10937E-11 300 END
Mo-95 10148 1.37409E-05 300 END
Mo-97 10148 0.000172767 300 END
Tc-99 10148 0.000176348 300 END
Ru-101 10148 0.000152268 300 END
Rh-103 10148 3.2763E-05 300 END
Rh-105 10148 6.85112E-08 300 END
Pd-105 10148 2.67687E-05 300 END
Cd-113 10148 7.61858E-08 300 END
Cs-133 10148 0.000247922 300 END
Cs-134 10148 6.31213E-07 300 END
La-139 10148 0.000258521 300 END
Ce-141 10148 0.000137911 300 END
Pr-141 10148 0.000100863 300 END
Pr-143 10148 8.17672E-05 300 END
Nd-143 10148 0.000193336 300 END
Nd-145 10148 0.000161626 300 END
Nd-147 10148 2.24231E-05 300 END
Pm-147 10148 0.000161626 300 END
Pm-149 10148 4.85053E-07 300 END
Sm-149 10148 7.48053E-06 300 END
Sm-150 10148 4.18376E-05 300 END
Sm-151 10148 1.01084E-05 300 END
Sm-152 10148 2.3242E-05 300 END
Eu-153 10148 6.76627E-06 300 END
Eu-154 10148 1.17637E-07 300 END
Eu-155 10148 1.12434E-06 300 END
Gd-155 10148 5.6068E-09 300 END
Gd-157 10148 2.13275E-08 300 END

' 2950 ρ= 6.2359 MWD= 4.649514524
h-zrh2 2950 0.099905594 300 END
u-235 2950 0.086793741 300 END
u-238 2950 0.397426524 300 END
zr-90 2950 2.907239247 300 END
zr-91 2950 0.634077453 300 END
zr-92 2950 0.969518678 300 END
zr-94 2950 0.982450199 300 END
zr-96 2950 0.158513064 300 END
U-236 2950 0.001874219 300 END
Pu-239 2950 0.000351026 300 END
Pu-240 2950 2.36308E-05 300 END
Pu-241 2950 3.12011E-08 300 END
Np-237 2950 3.10546E-06 300 END
Kr-83 2950 1.90072E-05 300 END
I-129 2950 3.17529E-05 300 END
I-131 2950 1.96462E-05 300 END
Xe-131 2950 0.0001576 300 END
Xe-133 2950 2.64757E-05 300 END
Xe-135 2950 3.06775E-11 300 END
Mo-95 2950 3.77745E-05 300 END
Mo-97 2950 0.000275716 300 END

Tc-99 2950 0.00028143 300 END
Ru-101 2950 0.000243002 300 END
Rh-103 2950 6.69651E-05 300 END
Rh-105 2950 6.88942E-08 300 END
Pd-105 2950 4.27197E-05 300 END
Cd-113 2950 7.50451E-08 300 END
Cs-133 2950 0.000395655 300 END
Cs-134 2950 1.66629E-06 300 END
La-139 2950 0.00041257 300 END
Ce-141 2950 0.000180638 300 END
Pr-141 2950 0.000199098 300 END
Pr-143 2950 9.40839E-05 300 END
Nd-143 2950 0.000308542 300 END
Nd-145 2950 0.000257936 300 END
Nd-147 2950 2.4974E-05 300 END
Pm-147 2950 0.000257936 300 END
Pm-149 2950 4.99348E-07 300 END
Sm-149 2950 7.61597E-06 300 END
Sm-150 2950 6.80347E-05 300 END
Sm-151 2950 1.19097E-05 300 END
Sm-152 2950 3.78998E-05 300 END
Eu-153 2950 1.13884E-05 300 END
Eu-154 2950 3.2749E-07 300 END
Eu-155 2950 1.51586E-06 300 END
Gd-155 2950 7.66106E-09 300 END
Gd-157 2950 2.14557E-08 300 END

' 2929   ρ= 6.2378 MWD= 4.552303568
h-zrh2 2929 0.099931651 300 END
u-235 2929 0.087084514 300 END
u-238 2929 0.397540046 300 END
zr-90 2929 2.907998751 300 END
zr-91 2929 0.634241744 300 END
zr-92 2929 0.969764298 300 END
zr-94 2929 0.982700866 300 END
zr-96 2929 0.15854852 300 END
U-236 2929 0.001835034 300 END
Pu-239 2929 0.000344687 300 END
Pu-240 2929 2.26761E-05 300 END
Pu-241 2929 3.0576E-08 300 END
Np-237 2929 2.97629E-06 300 END
Kr-83 2929 1.86098E-05 300 END
I-129 2929 3.1089E-05 300 END
I-131 2929 1.95962E-05 300 END
Xe-131 2929 0.000154305 300 END
Xe-133 2929 2.64565E-05 300 END
Xe-135 2929 3.07033E-11 300 END
Mo-95 2929 3.60933E-05 300 END
Mo-97 2929 0.000269952 300 END
Tc-99 2929 0.000275546 300 END
Ru-101 2929 0.000237922 300 END
Rh-103 2929 6.48733E-05 300 END
Rh-105 2929 6.88857E-08 300 END
Pd-105 2929 4.18266E-05 300 END
Cd-113 2929 7.5183E-08 300 END
Cs-133 2929 0.000387383 300 END
Cs-134 2929 1.59346E-06 300 END
La-139 2929 0.000403944 300 END
Ce-141 2929 0.000178744 300 END
Pr-141 2929 0.000193137 300 END
Pr-143 2929 9.363E-05 300 END
Nd-143 2929 0.000302091 300 END
Nd-145 2929 0.000252544 300 END
Nd-147 2929 2.48857E-05 300 END
Pm-147 2929 0.000252544 300 END

Pm-149 2929 4.98659E-07 300 END
Sm-149 2929 7.6134E-06 300 END
Sm-150 2929 6.65428E-05 300 END
Sm-151 2929 1.18441E-05 300 END
Sm-152 2929 3.70631E-05 300 END
Eu-153 2929 1.11179E-05 300 END
Eu-154 2929 3.12679E-07 300 END
Eu-155 2929 1.49642E-06 300 END
Gd-155 2929 7.55823E-09 300 END
Gd-157 2929 2.14511E-08 300 END

' 2955 ρ= 6.2453 MWD= 4.803115806
h-zrh2 2955 0.10006194 300 END
u-235 2955 0.086530935 300 END
u-238 2955 0.398033618 300 END
zr-90 2955 2.911787044 300 END
zr-91 2955 0.63507152 300 END
zr-92 2955 0.971046755 300 END
zr-94 2955 0.983995974 300 END
zr-96 2955 0.158769883 300 END
U-236 2955 0.001936136 300 END
Pu-239 2955 0.000360944 300 END
Pu-240 2955 2.51782E-05 300 END
Pu-241 2955 3.21868E-08 300 END
Np-237 2955 3.31558E-06 300 END
Kr-83 2955 1.96351E-05 300 END
I-129 2955 3.28019E-05 300 END
I-131 2955 1.97196E-05 300 END
Xe-131 2955 0.000162806 300 END
Xe-133 2955 2.65011E-05 300 END
Xe-135 2955 3.06364E-11 300 END
Mo-95 2955 4.05126E-05 300 END
Mo-97 2955 0.000284825 300 END
Tc-99 2955 0.000290728 300 END
Ru-101 2955 0.00025103 300 END
Rh-103 2955 7.03062E-05 300 END
Rh-105 2955 6.89054E-08 300 END
Pd-105 2955 4.4131E-05 300 END
Cd-113 2955 7.48174E-08 300 END
Cs-133 2955 0.000408726 300 END
Cs-134 2955 1.78517E-06 300 END
La-139 2955 0.0004262 300 END
Ce-141 2955 0.000183529 300 END
Pr-141 2955 0.000208614 300 END
Pr-143 2955 9.476E-05 300 END
Nd-143 2955 0.000318735 300 END
Nd-145 2955 0.000266458 300 END
Nd-147 2955 2.51043E-05 300 END
Pm-147 2955 0.000266458 300 END
Pm-149 2955 5.00422E-07 300 END
Sm-149 2955 7.61928E-06 300 END
Sm-150 2955 7.03981E-05 300 END
Sm-151 2955 1.20068E-05 300 END
Sm-152 2955 3.92258E-05 300 END
Eu-153 2955 1.18186E-05 300 END
Eu-154 2955 3.51655E-07 300 END
Eu-155 2955 1.54614E-06 300 END
Gd-155 2955 7.82126E-09 300 END
Gd-157 2955 2.14626E-08 300 END

' 2975 ρ= 6.262 MWD= 4.662005916
h-zrh2 2975 0.100322518 300 END
u-235 2975 0.087174777 300 END
u-238 2975 0.399085535 300 END
zr-90 2975 2.91937173 300 END

zr-91 2975 0.636723688 300 END
zr-92 2975 0.973564206 300 END
zr-94 2975 0.986549756 300 END
zr-96 2975 0.159174156 300 END
U-236 2975 0.001879255 300 END
Pu-239 2975 0.000351837 300 END
Pu-240 2975 2.37549E-05 300 END
Pu-241 2975 3.12814E-08 300 END
Np-237 2975 3.12227E-06 300 END
Kr-83 2975 1.90583E-05 300 END
I-129 2975 3.18382E-05 300 END
I-131 2975 1.96524E-05 300 END
Xe-131 2975 0.000158023 300 END
Xe-133 2975 2.6478E-05 300 END
Xe-135 2975 3.06742E-11 300 END
Mo-95 2975 3.79934E-05 300 END
Mo-97 2975 0.000276457 300 END
Tc-99 2975 0.000282187 300 END
Ru-101 2975 0.000243655 300 END
Rh-103 2975 6.72351E-05 300 END
Rh-105 2975 6.88952E-08 300 END
Pd-105 2975 4.28345E-05 300 END
Cd-113 2975 7.5027E-08 300 END
Cs-133 2975 0.000396718 300 END
Cs-134 2975 1.67578E-06 300 END
La-139 2975 0.000413678 300 END
Ce-141 2975 0.000180877 300 END
Pr-141 2975 0.000199868 300 END
Pr-143 2975 9.41408E-05 300 END
Nd-143 2975 0.000309371 300 END
Nd-145 2975 0.000258629 300 END
Nd-147 2975 2.4985E-05 300 END
Pm-147 2975 0.000258629 300 END
Pm-149 2975 4.99436E-07 300 END
Sm-149 2975 7.61627E-06 300 END
Sm-150 2975 6.82266E-05 300 END
Sm-151 2975 1.19179E-05 300 END
Sm-152 2975 3.80075E-05 300 END
Eu-153 2975 1.14233E-05 300 END
Eu-154 2975 3.29421E-07 300 END
Eu-155 2975 1.51835E-06 300 END
Gd-155 2975 7.67419E-09 300 END
Gd-157 2975 2.14563E-08 300 END

' 5845 ρ= 6.2445 MWD= 5.702992957
h-zrh2 5845 0.100088539 300 END
u-235 5845 0.083041732 300 END
u-238 5845 0.399020085 300 END
zr-90 5845 2.912549079 300 END
zr-91 5845 0.635252206 300 END
zr-92 5845 0.971371863 300 END
zr-94 5845 0.984308476 300 END
zr-96 5845 0.158865847 300 END
U-236 5845 0.002298876 300 END
Pu-239 5845 0.000416672 300 END
Pu-240 5845 3.51943E-05 300 END
Pu-241 5845 3.79104E-08 300 END
Np-237 5845 4.69771E-06 300 END
Kr-83 5845 2.33138E-05 300 END
I-129 5845 3.89474E-05 300 END
I-131 5845 2.00361E-05 300 END
Xe-131 5845 0.000193309 300 END
Xe-133 5845 2.65513E-05 300 END
Xe-135 5845 3.0387E-11 300 END
Mo-95 5845 5.85689E-05 300 END

Mo-97 5845 0.000338187 300 END
Tc-99 5845 0.000345196 300 END
Ru-101 5845 0.000298061 300 END
Rh-103 5845 9.06832E-05 300 END
Rh-105 5845 6.89224E-08 300 END
Pd-105 5845 5.23991E-05 300 END
Cd-113 5845 7.33047E-08 300 END
Cs-133 5845 0.000485302 300 END
Cs-134 5845 2.57917E-06 300 END
La-139 5845 0.000506049 300 END
Ce-141 5845 0.000198224 300 END
Pr-141 5845 0.000266553 300 END
Pr-143 5845 9.78613E-05 300 END
Nd-143 5845 0.000378451 300 END
Nd-145 5845 0.000316379 300 END
Nd-147 5845 2.56795E-05 300 END
Pm-147 5845 0.000316379 300 END
Pm-149 5845 5.0641E-07 300 END
Sm-149 5845 7.62386E-06 300 END
Sm-150 5845 8.43927E-05 300 END
Sm-151 5845 1.24407E-05 300 END
Sm-152 5845 4.70887E-05 300 END
Eu-153 5845 1.44081E-05 300 END
Eu-154 5845 5.12244E-07 300 END
Eu-155 5845 1.7139E-06 300 END
Gd-155 5845 8.71146E-09 300 END
Gd-157 5845 2.14957E-08 300 END

' 6932 ρ= 6.2776 MWD= 5.405617738
h-zrh2 6932 0.100605558 300 END
u-235 6932 0.083851871 300 END
u-238 6932 0.401581126 300 END
zr-90 6932 2.92759856 300 END
zr-91 6932 0.638529376 300 END
zr-92 6932 0.97636521 300 END
zr-94 6932 0.989374507 300 END
zr-96 6932 0.159666933 300 END
U-236 6932 0.002179005 300 END
Pu-239 6932 0.000398702 300 END
Pu-240 6932 3.17052E-05 300 END
Pu-241 6932 3.60286E-08 300 END
Np-237 6932 4.21198E-06 300 END
Kr-83 6932 2.20982E-05 300 END
I-129 6932 3.69166E-05 300 END
I-131 6932 1.99504E-05 300 END
Xe-131 6932 0.000183229 300 END
Xe-133 6932 2.65508E-05 300 END
Xe-135 6932 3.04709E-11 300 END
Mo-95 6932 5.22213E-05 300 END
Mo-97 6932 0.000320553 300 END
Tc-99 6932 0.000327197 300 END
Ru-101 6932 0.000282519 300 END
Rh-103 6932 8.38075E-05 300 END
Rh-105 6932 6.8925E-08 300 END
Pd-105 6932 4.96668E-05 300 END
Cd-113 6932 7.38316E-08 300 END
Cs-133 6932 0.000459996 300 END
Cs-134 6932 2.29791E-06 300 END
La-139 6932 0.000479662 300 END
Ce-141 6932 0.000193763 300 END
Pr-141 6932 0.000247014 300 END
Pr-143 6932 9.69819E-05 300 END
Nd-143 6932 0.000358717 300 END
Nd-145 6932 0.000299882 300 END
Nd-147 6932 2.55209E-05 300 END

Pm-147 6932 0.000299882 300 END
Pm-149 6932 5.04479E-07 300 END
Sm-149 6932 7.62476E-06 300 END
Sm-150 6932 7.97399E-05 300 END
Sm-151 6932 1.23204E-05 300 END
Sm-152 6932 4.44724E-05 300 END
Eu-153 6932 1.35393E-05 300 END
Eu-154 6932 4.55547E-07 300 END
Eu-155 6932 1.66009E-06 300 END
Gd-155 6932 8.42556E-09 300 END
Gd-157 6932 2.1486E-08 300 END

' 2932 ρ= 6.1416 MWD= 4.568199109
h-zrh2 2932 0.098394241 300 END
u-235 2932 0.085510651 300 END
u-238 2932 0.391416216 300 END
zr-90 2932 2.863259445 300 END
zr-91 2932 0.624484455 300 END
zr-92 2932 0.954850983 300 END
zr-94 2932 0.967587262 300 END
zr-96 2932 0.156114453 300 END
U-236 2932 0.001841441 300 END
Pu-239 2932 0.000345727 300 END
Pu-240 2932 2.28309E-05 300 END
Pu-241 2932 3.06783E-08 300 END
Np-237 2932 2.99721E-06 300 END
Kr-83 2932 1.86748E-05 300 END
I-129 2932 3.11976E-05 300 END
I-131 2932 1.96045E-05 300 END
Xe-131 2932 0.000154844 300 END
Xe-133 2932 2.64598E-05 300 END
Xe-135 2932 3.06991E-11 300 END
Mo-95 2932 3.63655E-05 300 END
Mo-97 2932 0.000270894 300 END
Tc-99 2932 0.000276509 300 END
Ru-101 2932 0.000238752 300 END
Rh-103 2932 6.52141E-05 300 END
Rh-105 2932 6.88872E-08 300 END
Pd-105 2932 4.19726E-05 300 END
Cd-113 2932 7.51608E-08 300 END
Cs-133 2932 0.000388735 300 END
Cs-134 2932 1.60524E-06 300 END
La-139 2932 0.000405355 300 END
Ce-141 2932 0.000179057 300 END
Pr-141 2932 0.000194108 300 END
Pr-143 2932 9.37056E-05 300 END
Nd-143 2932 0.000303146 300 END
Nd-145 2932 0.000253425 300 END
Nd-147 2932 2.49004E-05 300 END
Pm-147 2932 0.000253425 300 END
Pm-149 2932 4.98772E-07 300 END
Sm-149 2932 7.61384E-06 300 END
Sm-150 2932 6.67866E-05 300 END
Sm-151 2932 1.18551E-05 300 END
Sm-152 2932 3.71998E-05 300 END
Eu-153 2932 1.11621E-05 300 END
Eu-154 2932 3.15075E-07 300 END
Eu-155 2932 1.49961E-06 300 END
Gd-155 2932 7.57512E-09 300 END
Gd-157 2932 2.14518E-08 300 END

' 5915 ρ= 6.2448 MWD= 5.585077698
h-zrh2 5915 0.100088539 300 END
u-235 5915 0.083362969 300 END
u-238 5915 0.399032515 300 END

zr-90 5915 2.912550709 300 END
zr-91 5915 0.635250516 300 END
zr-92 5915 0.971363017 300 END
zr-94 5915 0.984301792 300 END
zr-96 5915 0.158858792 300 END
U-236 5915 0.002251345 300 END
Pu-239 5915 0.000409599 300 END
Pu-240 5915 3.37897E-05 300 END
Pu-241 5915 3.71653E-08 300 END
Np-237 5915 4.50163E-06 300 END
Kr-83 5915 2.28318E-05 300 END
I-129 5915 3.81422E-05 300 END
I-131 5915 2.00041E-05 300 END
Xe-131 5915 0.000189312 300 END
Xe-133 5915 2.65527E-05 300 END
Xe-135 5915 3.04204E-11 300 END
Mo-95 5915 5.6007E-05 300 END
Mo-97 5915 0.000331195 300 END
Tc-99 5915 0.000338059 300 END
Ru-101 5915 0.000291899 300 END
Rh-103 5915 8.79412E-05 300 END
Rh-105 5915 6.89243E-08 300 END
Pd-105 5915 5.13157E-05 300 END
Cd-113 5915 7.35161E-08 300 END
Cs-133 5915 0.000475268 300 END
Cs-134 5915 2.46536E-06 300 END
La-139 5915 0.000495586 300 END
Ce-141 5915 0.000196499 300 END
Pr-141 5915 0.000258762 300 END
Pr-143 5915 9.75279E-05 300 END
Nd-143 5915 0.000370626 300 END
Nd-145 5915 0.000309838 300 END
Nd-147 5915 2.56199E-05 300 END
Pm-147 5915 0.000309838 300 END
Pm-149 5915 5.05649E-07 300 END
Sm-149 5915 7.62446E-06 300 END
Sm-150 5915 8.25445E-05 300 END
Sm-151 5915 1.23955E-05 300 END
Sm-152 5915 4.60492E-05 300 END
Eu-153 5915 1.4062E-05 300 END
Eu-154 5915 4.8933E-07 300 END
Eu-155 5915 1.69274E-06 300 END
Gd-155 5915 8.59897E-09 300 END
Gd-157 5915 2.1492E-08 300 END

' 6886   ρ= 6.2767 MWD= 5.733465259
h-zrh2 6886 0.100605558 300 END
u-235 6886 0.082958716 300 END
u-238 6886 0.401546686 300 END
zr-90 6886 2.927594059 300 END
zr-91 6886 0.638534007 300 END
zr-92 6886 0.976389774 300 END
zr-94 6886 0.98939309 300 END
zr-96 6886 0.159686547 300 END
U-236 6886 0.00231116 300 END
Pu-239 6886 0.000418489 300 END
Pu-240 6886 3.55617E-05 300 END
Pu-241 6886 3.81027E-08 300 END
Np-237 6886 4.74912E-06 300 END
Kr-83 6886 2.34384E-05 300 END
I-129 6886 3.91556E-05 300 END
I-131 6886 2.0044E-05 300 END
Xe-131 6886 0.000194342 300 END
Xe-133 6886 2.65506E-05 300 END
Xe-135 6886 3.03784E-11 300 END

Mo-95 6886 5.92405E-05 300 END
Mo-97 6886 0.000339994 300 END
Tc-99 6886 0.000347041 300 END
Ru-101 6886 0.000299654 300 END
Rh-103 6886 9.1395E-05 300 END
Rh-105 6886 6.89217E-08 300 END
Pd-105 6886 5.26791E-05 300 END
Cd-113 6886 7.32496E-08 300 END
Cs-133 6886 0.000487895 300 END
Cs-134 6886 2.60908E-06 300 END
La-139 6886 0.000508753 300 END
Ce-141 6886 0.000198661 300 END
Pr-141 6886 0.000268575 300 END
Pr-143 6886 9.79443E-05 300 END
Nd-143 6886 0.000380473 300 END
Nd-145 6886 0.00031807 300 END
Nd-147 6886 2.56942E-05 300 END
Pm-147 6886 0.00031807 300 END
Pm-149 6886 5.06605E-07 300 END
Sm-149 6886 7.62365E-06 300 END
Sm-150 6886 8.48711E-05 300 END
Sm-151 6886 1.24519E-05 300 END
Sm-152 6886 4.73578E-05 300 END
Eu-153 6886 1.44979E-05 300 END
Eu-154 6886 5.18258E-07 300 END
Eu-155 6886 1.71934E-06 300 END
Gd-155 6886 8.74034E-09 300 END
Gd-157 6886 2.14967E-08 300 END

' 5912 ρ= 6.2446 MWD= 5.65253719
h-zrh2 5912 0.100088539 300 END
u-235 5912 0.083179189 300 END
u-238 5912 0.399025412 300 END
zr-90 5912 2.912549778 300 END
zr-91 5912 0.635251478 300 END
zr-92 5912 0.971368076 300 END
zr-94 5912 0.984305616 300 END
zr-96 5912 0.158862828 300 END
U-236 5912 0.002278538 300 END
Pu-239 5912 0.000413654 300 END
Pu-240 5912 3.45899E-05 300 END
Pu-241 5912 3.75918E-08 300 END
Np-237 5912 4.61324E-06 300 END
Kr-83 5912 2.31076E-05 300 END
I-129 5912 3.86029E-05 300 END
I-131 5912 2.00227E-05 300 END
Xe-131 5912 0.000191598 300 END
Xe-133 5912 2.65521E-05 300 END
Xe-135 5912 3.04014E-11 300 END
Mo-95 5912 5.74655E-05 300 END
Mo-97 5912 0.000335195 300 END
Tc-99 5912 0.000342142 300 END
Ru-101 5912 0.000295424 300 END
Rh-103 5912 8.95074E-05 300 END
Rh-105 5912 6.89234E-08 300 END
Pd-105 5912 5.19355E-05 300 END
Cd-113 5912 7.33955E-08 300 END
Cs-133 5912 0.000481008 300 END
Cs-134 5912 2.5301E-06 300 END
La-139 5912 0.000501572 300 END
Ce-141 5912 0.000197493 300 END
Pr-141 5912 0.000263212 300 END
Pr-143 5912 9.77211E-05 300 END
Nd-143 5912 0.000375102 300 END
Nd-145 5912 0.00031358 300 END

Nd-147 5912 2.56545E-05 300 END
Pm-147 5912 0.00031358 300 END
Pm-149 5912 5.06085E-07 300 END
Sm-149 5912 7.62416E-06 300 END
Sm-150 5912 8.36013E-05 300 END
Sm-151 5912 1.24218E-05 300 END
Sm-152 5912 4.66435E-05 300 END
Eu-153 5912 1.42598E-05 300 END
Eu-154 5912 5.02369E-07 300 END
Eu-155 5912 1.70487E-06 300 END
Gd-155 5912 8.66346E-09 300 END
Gd-157 5912 2.14941E-08 300 END

' 5846 ρ= 6.2431 MWD= 6.237693173
h-zrh2 5846 0.100088539 300 END
u-235 5846 0.081585048 300 END
u-238 5846 0.398962874 300 END
zr-90 5846 2.912541464 300 END
zr-91 5846 0.635260357 300 END
zr-92 5846 0.971412188 300 END
zr-94 5846 0.984338785 300 END
zr-96 5846 0.158897836 300 END
U-236 5846 0.002514414 300 END
Pu-239 5846 0.00044789 300 END
Pu-240 5846 4.19101E-05 300 END
Pu-241 5846 4.12706E-08 300 END
Np-237 5846 5.64506E-06 300 END
Kr-83 5846 2.54997E-05 300 END
I-129 5846 4.25991E-05 300 END
I-131 5846 2.0153E-05 300 END
Xe-131 5846 0.000211433 300 END
Xe-133 5846 2.65214E-05 300 END
Xe-135 5846 3.02336E-11 300 END
Mo-95 5846 7.09241E-05 300 END
Mo-97 5846 0.000369895 300 END
Tc-99 5846 0.000377561 300 END
Ru-101 5846 0.000326007 300 END
Rh-103 5846 0.000103356 300 END
Rh-105 5846 6.89005E-08 300 END
Pd-105 5846 5.73119E-05 300 END
Cd-113 5846 7.23138E-08 300 END
Cs-133 5846 0.000530803 300 END
Cs-134 5846 3.13398E-06 300 END
La-139 5846 0.000553495 300 END
Ce-141 5846 0.000205386 300 END
Pr-141 5846 0.000302565 300 END
Pr-143 5846 9.91467E-05 300 END
Nd-143 5846 0.000413933 300 END
Nd-145 5846 0.000346042 300 END
Nd-147 5846 2.59015E-05 300 END
Pm-147 5846 0.000346042 300 END
Pm-149 5846 5.09794E-07 300 END
Sm-149 5846 7.61762E-06 300 END
Sm-150 5846 9.28286E-05 300 END
Sm-151 5846 1.26098E-05 300 END
Sm-152 5846 5.18376E-05 300 END
Eu-153 5846 1.60028E-05 300 END
Eu-154 5846 6.23347E-07 300 END
Eu-155 5846 1.80734E-06 300 END
Gd-155 5846 9.20851E-09 300 END
Gd-157 5846 2.15109E-08 300 END

' 5903 ρ= 6.2082 MWD= 6.157193394
h-zrh2 5903 0.09952582 300 END
u-235 5903 0.081804354 300 END

u-238 5903 0.396218137 300 END
zr-90 5903 2.896167336 300 END
zr-91 5903 0.631687677 300 END
zr-92 5903 0.965947131 300 END
zr-94 5903 0.978802048 300 END
zr-96 5903 0.15800176 300 END
U-236 5903 0.002481965 300 END
Pu-239 5903 0.000443279 300 END
Pu-240 5903 4.08628E-05 300 END
Pu-241 5903 4.07666E-08 300 END
Np-237 5903 5.49626E-06 300 END
Kr-83 5903 2.51706E-05 300 END
I-129 5903 4.20493E-05 300 END
I-131 5903 2.01381E-05 300 END
Xe-131 5903 0.000208704 300 END
Xe-133 5903 2.65281E-05 300 END
Xe-135 5903 3.02569E-11 300 END
Mo-95 5903 6.89868E-05 300 END
Mo-97 5903 0.000365122 300 END
Tc-99 5903 0.000372689 300 END
Ru-101 5903 0.0003218 300 END
Rh-103 5903 0.000101424 300 END
Rh-105 5903 6.89051E-08 300 END
Pd-105 5903 5.65723E-05 300 END
Cd-113 5903 7.24657E-08 300 END
Cs-133 5903 0.000523953 300 END
Cs-134 5903 3.04632E-06 300 END
La-139 5903 0.000546352 300 END
Ce-141 5903 0.000204374 300 END
Pr-141 5903 0.000297074 300 END
Pr-143 5903 9.89752E-05 300 END
Nd-143 5903 0.000408591 300 END
Nd-145 5903 0.000341576 300 END
Nd-147 5903 2.58727E-05 300 END
Pm-147 5903 0.000341576 300 END
Pm-149 5903 5.09291E-07 300 END
Sm-149 5903 7.61889E-06 300 END
Sm-150 5903 9.15528E-05 300 END
Sm-151 5903 1.25879E-05 300 END
Sm-152 5903 5.1119E-05 300 END
Eu-153 5903 1.57601E-05 300 END
Eu-154 5903 6.05861E-07 300 END
Eu-155 5903 1.79352E-06 300 END
Gd-155 5903 9.13494E-09 300 END
Gd-157 5903 2.15088E-08 300 END

' 5917   ρ= 6.2787 MWD= 4.98041615
h-zrh2 5917 0.100605558 300 END
u-235 5917 0.085010248 300 END
u-238 5917 0.401625015 300 END
zr-90 5917 2.927604192 300 END
zr-91 5917 0.638523838 300 END
zr-92 5917 0.976333548 300 END
zr-94 5917 0.989350404 300 END
zr-96 5917 0.159641495 300 END
U-236 5917 0.002007606 300 END
Pu-239 5917 0.000372244 300 END
Pu-240 5917 2.70234E-05 300 END
Pu-241 5917 3.33214E-08 300 END
Np-237 5917 3.56734E-06 300 END
Kr-83 5917 2.03599E-05 300 END
I-129 5917 3.40128E-05 300 END
I-131 5917 1.97965E-05 300 END
Xe-131 5917 0.000168816 300 END
Xe-133 5917 2.65234E-05 300 END

Xe-135 5917 3.05883E-11 300 END
Mo-95 5917 4.37979E-05 300 END
Mo-97 5917 0.000295339 300 END
Tc-99 5917 0.00030146 300 END
Ru-101 5917 0.000260296 300 END
Rh-103 5917 7.42156E-05 300 END
Rh-105 5917 6.89149E-08 300 END
Pd-105 5917 4.57601E-05 300 END
Cd-113 5917 7.45412E-08 300 END
Cs-133 5917 0.000423813 300 END
Cs-134 5917 1.9283E-06 300 END
La-139 5917 0.000441932 300 END
Ce-141 5917 0.000186718 300 END
Pr-141 5917 0.000219741 300 END
Pr-143 5917 9.54815E-05 300 END
Nd-143 5917 0.0003305 300 END
Nd-145 5917 0.000276294 300 END
Nd-147 5917 2.52417E-05 300 END
Pm-147 5917 0.000276294 300 END
Pm-149 5917 5.01639E-07 300 END
Sm-149 5917 7.62206E-06 300 END
Sm-150 5917 7.31353E-05 300 END
Sm-151 5917 1.21098E-05 300 END
Sm-152 5917 4.07622E-05 300 END
Eu-153 5917 1.23194E-05 300 END
Eu-154 5917 3.80715E-07 300 END
Eu-155 5917 1.58043E-06 300 END
Gd-155 5917 8.00291E-09 300 END
Gd-157 5917 2.14701E-08 300 END

' 6929 ρ= 6.2445 MWD= 5.715356964
h-zrh2 6929 0.100088539 300 END
u-235 6929 0.083008049 300 END
u-238 6929 0.399018778 300 END
zr-90 6929 2.912548907 300 END
zr-91 6929 0.635252386 300 END
zr-92 6929 0.971372791 300 END
zr-94 6929 0.984309177 300 END
zr-96 6929 0.158866586 300 END
U-236 6929 0.00230386 300 END
Pu-239 6929 0.00041741 300 END
Pu-240 6929 3.53431E-05 300 END
Pu-241 6929 3.79884E-08 300 END
Np-237 6929 4.71853E-06 300 END
Kr-83 6929 2.33644E-05 300 END
I-129 6929 3.90319E-05 300 END
I-131 6929 2.00393E-05 300 END
Xe-131 6929 0.000193728 300 END
Xe-133 6929 2.6551E-05 300 END
Xe-135 6929 3.03835E-11 300 END
Mo-95 6929 5.88409E-05 300 END
Mo-97 6929 0.000338921 300 END
Tc-99 6929 0.000345945 300 END
Ru-101 6929 0.000298707 300 END
Rh-103 6929 9.09719E-05 300 END
Rh-105 6929 6.89221E-08 300 END
Pd-105 6929 5.25127E-05 300 END
Cd-113 6929 7.32823E-08 300 END
Cs-133 6929 0.000486354 300 END
Cs-134 6929 2.59128E-06 300 END
La-139 6929 0.000507146 300 END
Ce-141 6929 0.000198402 300 END
Pr-141 6929 0.000267373 300 END
Pr-143 6929 9.78952E-05 300 END
Nd-143 6929 0.000379271 300 END

Nd-145 6929 0.000317065 300 END
Nd-147 6929 2.56855E-05 300 END
Pm-147 6929 0.000317065 300 END
Pm-149 6929 5.06489E-07 300 END
Sm-149 6929 7.62378E-06 300 END
Sm-150 6929 8.45868E-05 300 END
Sm-151 6929 1.24453E-05 300 END
Sm-152 6929 4.71979E-05 300 END
Eu-153 6929 1.44445E-05 300 END
Eu-154 6929 5.14679E-07 300 END
Eu-155 6929 1.71611E-06 300 END
Gd-155 6929 8.72319E-09 300 END
Gd-157 6929 2.14961E-08 300 END

' 6925 ρ= 6.2454 MWD= 5.361494991
h-zrh2 6925 0.100088539 300 END
u-235 6925 0.083972075 300 END
u-238 6925 0.399055897 300 END
zr-90 6925 2.91255375 300 END
zr-91 6925 0.635247419 300 END
zr-92 6925 0.971346292 300 END
zr-94 6925 0.984289118 300 END
zr-96 6925 0.158845416 300 END
U-236 6925 0.002161219 300 END
Pu-239 6925 0.000395999 300 END
Pu-240 6925 3.12026E-05 300 END
Pu-241 6925 3.57485E-08 300 END
Np-237 6925 4.14238E-06 300 END
Kr-83 6925 2.19178E-05 300 END
I-129 6925 3.66153E-05 300 END
I-131 6925 1.99362E-05 300 END
Xe-131 6925 0.000181733 300 END
Xe-133 6925 2.65495E-05 300 END
Xe-135 6925 3.04832E-11 300 END
Mo-95 6925 5.13115E-05 300 END
Mo-97 6925 0.000317937 300 END
Tc-99 6925 0.000324526 300 END
Ru-101 6925 0.000280213 300 END
Rh-103 6925 8.27986E-05 300 END
Rh-105 6925 6.89248E-08 300 END
Pd-105 6925 4.92614E-05 300 END
Cd-113 6925 7.39079E-08 300 END
Cs-133 6925 0.000456242 300 END
Cs-134 6925 2.25779E-06 300 END
La-139 6925 0.000475747 300 END
Ce-141 6925 0.000193069 300 END
Pr-141 6925 0.000244147 300 END
Pr-143 6925 9.68401E-05 300 END
Nd-143 6925 0.000355789 300 END
Nd-145 6925 0.000297434 300 END
Nd-147 6925 2.5495E-05 300 END
Pm-147 6925 0.000297434 300 END
Pm-149 6925 5.04189E-07 300 END
Sm-149 6925 7.62471E-06 300 END
Sm-150 6925 7.90519E-05 300 END
Sm-151 6925 1.23007E-05 300 END
Sm-152 6925 4.40857E-05 300 END
Eu-153 6925 1.34114E-05 300 END
Eu-154 6925 4.47442E-07 300 END
Eu-155 6925 1.65198E-06 300 END
Gd-155 6925 8.38249E-09 300 END
Gd-157 6925 2.14844E-08 300 END

' 5844 ρ= 6.2448 MWD= 5.572441778
h-zrh2 5844 0.100088539 300 END

u-235 5844 0.083397393 300 END
u-238 5844 0.399033843 300 END
zr-90 5844 2.912550882 300 END
zr-91 5844 0.635250337 300 END
zr-92 5844 0.971362071 300 END
zr-94 5844 0.984301076 300 END
zr-96 5844 0.158858036 300 END
U-236 5844 0.002246251 300 END
Pu-239 5844 0.000408837 300 END
Pu-240 5844 3.36408E-05 300 END
Pu-241 5844 3.70854E-08 300 END
Np-237 5844 4.48089E-06 300 END
Kr-83 5844 2.27801E-05 300 END
I-129 5844 3.80559E-05 300 END
I-131 5844 2.00005E-05 300 END
Xe-131 5844 0.000188883 300 END
Xe-133 5844 2.65527E-05 300 END
Xe-135 5844 3.0424E-11 300 END
Mo-95 5844 5.5736E-05 300 END
Mo-97 5844 0.000330446 300 END
Tc-99 5844 0.000337294 300 END
Ru-101 5844 0.000291238 300 END
Rh-103 5844 8.76486E-05 300 END
Rh-105 5844 6.89245E-08 300 END
Pd-105 5844 5.11996E-05 300 END
Cd-113 5844 7.35386E-08 300 END
Cs-133 5844 0.000474193 300 END
Cs-134 5844 2.45334E-06 300 END
La-139 5844 0.000494465 300 END
Ce-141 5844 0.00019631 300 END
Pr-141 5844 0.00025793 300 END
Pr-143 5844 9.7491E-05 300 END
Nd-143 5844 0.000369787 300 END
Nd-145 5844 0.000309137 300 END
Nd-147 5844 2.56133E-05 300 END
Pm-147 5844 0.000309137 300 END
Pm-149 5844 5.05567E-07 300 END
Sm-149 5844 7.62451E-06 300 END
Sm-150 5844 8.23467E-05 300 END
Sm-151 5844 1.23904E-05 300 END
Sm-152 5844 4.59379E-05 300 END
Eu-153 5844 1.40251E-05 300 END
Eu-154 5844 4.86908E-07 300 END
Eu-155 5844 1.69046E-06 300 END
Gd-155 5844 8.58685E-09 300 END
Gd-157 5844 2.14916E-08 300 END

' 6923   ρ= 6.2786 MWD= 5.007953057
h-zrh2 6923 0.100605558 300 END
u-235 6923 0.084935229 300 END
u-238 6923 0.401622199 300 END
zr-90 6923 2.927603835 300 END
zr-91 6923 0.63852418 300 END
zr-92 6923 0.976335592 300 END
zr-94 6923 0.989351965 300 END
zr-96 6923 0.159643142 300 END
U-236 6923 0.002018706 300 END
Pu-239 6923 0.000373985 300 END
Pu-240 6923 2.73156E-05 300 END
Pu-241 6923 3.34973E-08 300 END
Np-237 6923 3.60733E-06 300 END
Kr-83 6923 2.04725E-05 300 END
I-129 6923 3.42008E-05 300 END
I-131 6923 1.98077E-05 300 END
Xe-131 6923 0.00016975 300 END

Xe-133 6923 2.65263E-05 300 END
Xe-135 6923 3.05808E-11 300 END
Mo-95 6923 4.43201E-05 300 END
Mo-97 6923 0.000296972 300 END
Tc-99 6923 0.000303126 300 END
Ru-101 6923 0.000261736 300 END
Rh-103 6923 7.48278E-05 300 END
Rh-105 6923 6.89161E-08 300 END
Pd-105 6923 4.60131E-05 300 END
Cd-113 6923 7.44972E-08 300 END
Cs-133 6923 0.000426157 300 END
Cs-134 6923 1.9511E-06 300 END
La-139 6923 0.000444376 300 END
Ce-141 6923 0.000187199 300 END
Pr-141 6923 0.000221483 300 END
Pr-143 6923 9.55883E-05 300 END
Nd-143 6923 0.000332328 300 END
Nd-145 6923 0.000277821 300 END
Nd-147 6923 2.52619E-05 300 END
Pm-147 6923 0.000277821 300 END
Pm-149 6923 5.01827E-07 300 END
Sm-149 6923 7.62239E-06 300 END
Sm-150 6923 7.35613E-05 300 END
Sm-151 6923 1.21249E-05 300 END
Sm-152 6923 4.10013E-05 300 END
Eu-153 6923 1.23976E-05 300 END
Eu-154 6923 3.85341E-07 300 END
Eu-155 6923 1.58569E-06 300 END
Gd-155 6923 8.03082E-09 300 END
Gd-157 6923 2.14712E-08 300 END

' 5919   ρ= 6.2451 MWD= 5.489808623
h-zrh2 5919 0.100088539 300 END
u-235 5919 0.08362251 300 END
u-238 5919 0.399042508 300 END
zr-90 5919 2.912552012 300 END
zr-91 5919 0.635249178 300 END
zr-92 5919 0.971355883 300 END
zr-94 5919 0.984296392 300 END
zr-96 5919 0.158853093 300 END
U-236 5919 0.002212942 300 END
Pu-239 5919 0.000403834 300 END
Pu-240 5919 3.26751E-05 300 END
Pu-241 5919 3.65623E-08 300 END
Np-237 5919 4.34656E-06 300 END
Kr-83 5919 2.24423E-05 300 END
I-129 5919 3.74916E-05 300 END
I-131 5919 1.99764E-05 300 END
Xe-131 5919 0.000186083 300 END
Xe-133 5919 2.65523E-05 300 END
Xe-135 5919 3.04473E-11 300 END
Mo-95 5919 5.39803E-05 300 END
Mo-97 5919 0.000325546 300 END
Tc-99 5919 0.000332293 300 END
Ru-101 5919 0.000286919 300 END
Rh-103 5919 8.57407E-05 300 END
Rh-105 5919 6.8925E-08 300 END
Pd-105 5919 5.04404E-05 300 END
Cd-113 5919 7.36846E-08 300 END
Cs-133 5919 0.000467161 300 END
Cs-134 5919 2.3756E-06 300 END
La-139 5919 0.000487133 300 END
Ce-141 5919 0.000195063 300 END
Pr-141 5919 0.000252509 300 END
Pr-143 5919 9.7244E-05 300 END

Nd-143 5919 0.000364304 300 END
Nd-145 5919 0.000304553 300 END
Nd-147 5919 2.55687E-05 300 END
Pm-147 5919 0.000304553 300 END
Pm-149 5919 5.0503E-07 300 END
Sm-149 5919 7.62472E-06 300 END
Sm-150 5919 8.10544E-05 300 END
Sm-151 5919 1.23566E-05 300 END
Sm-152 5919 4.52113E-05 300 END
Eu-153 5919 1.37839E-05 300 END
Eu-154 5919 4.71232E-07 300 END
Eu-155 5919 1.67548E-06 300 END
Gd-155 5919 8.50725E-09 300 END
Gd-157 5919 2.14888E-08 300 END

' 5921   ρ= 6.2448 MWD= 5.590929383
h-zrh2 5921 0.100088539 300 END
u-235 5921 0.083347027 300 END
u-238 5921 0.3990319 300 END
zr-90 5921 2.912550628 300 END
zr-91 5921 0.635250599 300 END
zr-92 5921 0.971363456 300 END
zr-94 5921 0.984302123 300 END
zr-96 5921 0.158859142 300 END
U-236 5921 0.002253704 300 END
Pu-239 5921 0.000409952 300 END
Pu-240 5921 3.38587E-05 300 END
Pu-241 5921 3.72023E-08 300 END
Np-237 5921 4.51126E-06 300 END
Kr-83 5921 2.28557E-05 300 END
I-129 5921 3.81821E-05 300 END
I-131 5921 2.00057E-05 300 END
Xe-131 5921 0.00018951 300 END
Xe-133 5921 2.65527E-05 300 END
Xe-135 5921 3.04188E-11 300 END
Mo-95 5921 5.61328E-05 300 END
Mo-97 5921 0.000331542 300 END
Tc-99 5921 0.000338413 300 END
Ru-101 5921 0.000292204 300 END
Rh-103 5921 8.80768E-05 300 END
Rh-105 5921 6.89242E-08 300 END
Pd-105 5921 5.13695E-05 300 END
Cd-113 5921 7.35057E-08 300 END
Cs-133 5921 0.000475766 300 END
Cs-134 5921 2.47093E-06 300 END
La-139 5921 0.000496106 300 END
Ce-141 5921 0.000196586 300 END
Pr-141 5921 0.000259147 300 END
Pr-143 5921 9.75449E-05 300 END
Nd-143 5921 0.000371014 300 END
Nd-145 5921 0.000310162 300 END
Nd-147 5921 2.5623E-05 300 END
Pm-147 5921 0.000310162 300 END
Pm-149 5921 5.05687E-07 300 END
Sm-149 5921 7.62444E-06 300 END
Sm-150 5921 8.26361E-05 300 END
Sm-151 5921 1.23978E-05 300 END
Sm-152 5921 4.61007E-05 300 END
Eu-153 5921 1.40792E-05 300 END
Eu-154 5921 4.90454E-07 300 END
Eu-155 5921 1.69379E-06 300 END
Gd-155 5921 8.60458E-09 300 END
Gd-157 5921 2.14922E-08 300 END

' 6927   ρ= 6.2769 MWD= 5.64784857

h-zrh2 6927 0.100605558 300 END
u-235 6927 0.083191962 300 END
u-238 6927 0.40155573 300 END
zr-90 6927 2.927595248 300 END
zr-91 6927 0.638532768 300 END
zr-92 6927 0.976383347 300 END
zr-94 6927 0.989388237 300 END
zr-96 6927 0.159681425 300 END
U-236 6927 0.002276648 300 END
Pu-239 6927 0.000413373 300 END
Pu-240 6927 3.45339E-05 300 END
Pu-241 6927 3.75621E-08 300 END
Np-237 6927 4.60544E-06 300 END
Kr-83 6927 2.30884E-05 300 END
I-129 6927 3.85709E-05 300 END
I-131 6927 2.00214E-05 300 END
Xe-131 6927 0.000191439 300 END
Xe-133 6927 2.65522E-05 300 END
Xe-135 6927 3.04027E-11 300 END
Mo-95 6927 5.73635E-05 300 END
Mo-97 6927 0.000334917 300 END
Tc-99 6927 0.000341859 300 END
Ru-101 6927 0.000295179 300 END
Rh-103 6927 8.93984E-05 300 END
Rh-105 6927 6.89234E-08 300 END
Pd-105 6927 5.18924E-05 300 END
Cd-113 6927 7.3404E-08 300 END
Cs-133 6927 0.000480609 300 END
Cs-134 6927 2.52557E-06 300 END
La-139 6927 0.000501156 300 END
Ce-141 6927 0.000197424 300 END
Pr-141 6927 0.000262902 300 END
Pr-143 6927 9.77078E-05 300 END
Nd-143 6927 0.000374791 300 END
Nd-145 6927 0.00031332 300 END
Nd-147 6927 2.56521E-05 300 END
Pm-147 6927 0.00031332 300 END
Pm-149 6927 5.06055E-07 300 END
Sm-149 6927 7.62418E-06 300 END
Sm-150 6927 8.35278E-05 300 END
Sm-151 6927 1.242E-05 300 END
Sm-152 6927 4.66022E-05 300 END
Eu-153 6927 1.4246E-05 300 END
Eu-154 6927 5.01457E-07 300 END
Eu-155 6927 1.70403E-06 300 END
Gd-155 6927 8.65899E-09 300 END
Gd-157 6927 2.1494E-08 300 END

' 5902   ρ= 6.2434 MWD= 6.105462079
h-zrh2 5902 0.100088539 300 END
u-235 5902 0.081945285 300 END
u-238 5902 0.398977152 300 END
zr-90 5902 2.912543381 300 END
zr-91 5902 0.635258269 300 END
zr-92 5902 0.971402183 300 END
zr-94 5902 0.984331289 300 END
zr-96 5902 0.158889925 300 END
U-236 5902 0.002461112 300 END
Pu-239 5902 0.000440299 300 END
Pu-240 5902 4.01965E-05 300 END
Pu-241 5902 4.04424E-08 300 END
Np-237 5902 5.40181E-06 300 END
Kr-83 5902 2.49591E-05 300 END
I-129 5902 4.1696E-05 300 END
I-131 5902 2.01281E-05 300 END

Xe-131 5902 0.000206951 300 END
Xe-133 5902 2.65321E-05 300 END
Xe-135 5902 3.02718E-11 300 END
Mo-95 5902 6.77563E-05 300 END
Mo-97 5902 0.000362054 300 END
Tc-99 5902 0.000369558 300 END
Ru-101 5902 0.000319096 300 END
Rh-103 5902 0.000100187 300 END
Rh-105 5902 6.89078E-08 300 END
Pd-105 5902 5.6097E-05 300 END
Cd-113 5902 7.25629E-08 300 END
Cs-133 5902 0.00051955 300 END
Cs-134 5902 2.99077E-06 300 END
La-139 5902 0.000541762 300 END
Ce-141 5902 0.000203712 300 END
Pr-141 5902 0.000293559 300 END
Pr-143 5902 9.8861E-05 300 END
Nd-143 5902 0.000405158 300 END
Nd-145 5902 0.000338707 300 END
Nd-147 5902 2.58534E-05 300 END
Pm-147 5902 0.000338707 300 END
Pm-149 5902 5.08966E-07 300 END
Sm-149 5902 7.61965E-06 300 END
Sm-150 5902 9.07341E-05 300 END
Sm-151 5902 1.25732E-05 300 END
Sm-152 5902 5.06579E-05 300 END
Eu-153 5902 1.56046E-05 300 END
Eu-154 5902 5.94767E-07 300 END
Eu-155 5902 1.78459E-06 300 END
Gd-155 5902 9.08744E-09 300 END
Gd-157 5902 2.15074E-08 300 END

' 5904   ρ= 6.2434 MWD= 6.116506064
h-zrh2 5904 0.100088539 300 END
u-235 5904 0.081915198 300 END
u-238 5904 0.398975963 300 END
zr-90 5904 2.912543222 300 END
zr-91 5904 0.635258442 300 END
zr-92 5904 0.971403018 300 END
zr-94 5904 0.984331915 300 END
zr-96 5904 0.158890585 300 END
U-236 5904 0.002465564 300 END
Pu-239 5904 0.000440937 300 END
Pu-240 5904 4.03383E-05 300 END
Pu-241 5904 4.05116E-08 300 END
Np-237 5904 5.4219E-06 300 END
Kr-83 5904 2.50043E-05 300 END
I-129 5904 4.17715E-05 300 END
I-131 5904 2.01302E-05 300 END
Xe-131 5904 0.000207325 300 END
Xe-133 5904 2.65312E-05 300 END
Xe-135 5904 3.02686E-11 300 END
Mo-95 5904 6.8018E-05 300 END
Mo-97 5904 0.000362709 300 END
Tc-99 5904 0.000370226 300 END
Ru-101 5904 0.000319673 300 END
Rh-103 5904 0.000100451 300 END
Rh-105 5904 6.89072E-08 300 END
Pd-105 5904 5.61985E-05 300 END
Cd-113 5904 7.25422E-08 300 END
Cs-133 5904 0.00052049 300 END
Cs-134 5904 3.00258E-06 300 END
La-139 5904 0.000542742 300 END
Ce-141 5904 0.000203854 300 END
Pr-141 5904 0.000294308 300 END

Pr-143 5904 9.88857E-05 300 END
Nd-143 5904 0.000405891 300 END
Nd-145 5904 0.000339319 300 END
Nd-147 5904 2.58576E-05 300 END
Pm-147 5904 0.000339319 300 END
Pm-149 5904 5.09035E-07 300 END
Sm-149 5904 7.6195E-06 300 END
Sm-150 5904 9.09088E-05 300 END
Sm-151 5904 1.25763E-05 300 END
Sm-152 5904 5.07563E-05 300 END
Eu-153 5904 1.56377E-05 300 END
Eu-154 5904 5.97126E-07 300 END
Eu-155 5904 1.7865E-06 300 END
Gd-155 5904 9.09759E-09 300 END
Gd-157 5904 2.15077E-08 300 END

' 6930 ρ= 6.277 MWD= 5.622593014
h-zrh2 6930 0.100605558 300 END
u-235 6930 0.083260766 300 END
u-238 6930 0.401558391 300 END
zr-90 6930 2.927595597 300 END
zr-91 6930 0.638532407 300 END
zr-92 6930 0.976381452 300 END
zr-94 6930 0.989386806 300 END
zr-96 6930 0.159679914 300 END
U-236 6930 0.002266467 300 END
Pu-239 6930 0.000411857 300 END
Pu-240 6930 3.42336E-05 300 END
Pu-241 6930 3.74025E-08 300 END
Np-237 6930 4.56352E-06 300 END
Kr-83 6930 2.29852E-05 300 END
I-129 6930 3.83984E-05 300 END
I-131 6930 2.00145E-05 300 END
Xe-131 6930 0.000190583 300 END
Xe-133 6930 2.65525E-05 300 END
Xe-135 6930 3.04098E-11 300 END
Mo-95 6930 5.68157E-05 300 END
Mo-97 6930 0.00033342 300 END
Tc-99 6930 0.00034033 300 END
Ru-101 6930 0.000293859 300 END
Rh-103 6930 8.88114E-05 300 END
Rh-105 6930 6.89238E-08 300 END
Pd-105 6930 5.16604E-05 300 END
Cd-113 6930 7.34492E-08 300 END
Cs-133 6930 0.00047846 300 END
Cs-134 6930 2.50124E-06 300 END
La-139 6930 0.000498915 300 END
Ce-141 6930 0.000197054 300 END
Pr-141 6930 0.000261234 300 END
Pr-143 6930 9.76361E-05 300 END
Nd-143 6930 0.000373115 300 END
Nd-145 6930 0.000311919 300 END
Nd-147 6930 2.56393E-05 300 END
Pm-147 6930 0.000311919 300 END
Pm-149 6930 5.05892E-07 300 END
Sm-149 6930 7.6243E-06 300 END
Sm-150 6930 8.3132E-05 300 END
Sm-151 6930 1.24102E-05 300 END
Sm-152 6930 4.63796E-05 300 END
Eu-153 6930 1.41719E-05 300 END
Eu-154 6930 4.96558E-07 300 END
Eu-155 6930 1.6995E-06 300 END
Gd-155 6930 8.63488E-09 300 END
Gd-157 6930 2.14932E-08 300 END

' 6889   ρ= 6.2782 MWD= 5.180456095
h-zrh2 6889 0.100605558 300 END
u-235 6889 0.084465279 300 END
u-238 6889 0.401604476 300 END
zr-90 6889 2.927601571 300 END
zr-91 6889 0.638526376 300 END
zr-92 6889 0.976348416 300 END
zr-94 6889 0.989361743 300 END
zr-96 6889 0.159653462 300 END
U-236 6889 0.002088242 300 END
Pu-239 6889 0.000384804 300 END
Pu-240 6889 2.91809E-05 300 END
Pu-241 6889 3.45974E-08 300 END
Np-237 6889 3.86338E-06 300 END
Kr-83 6889 2.11777E-05 300 END
I-129 6889 3.53789E-05 300 END
I-131 6889 1.98739E-05 300 END
Xe-131 6889 0.000175597 300 END
Xe-133 6889 2.65406E-05 300 END
Xe-135 6889 3.05334E-11 300 END
Mo-95 6889 4.7665E-05 300 END
Mo-97 6889 0.000307201 300 END
Tc-99 6889 0.000313568 300 END
Ru-101 6889 0.000270751 300 END
Rh-103 6889 7.86915E-05 300 END
Rh-105 6889 6.89218E-08 300 END
Pd-105 6889 4.7598E-05 300 END
Cd-113 6889 7.42148E-08 300 END
Cs-133 6889 0.000440836 300 END
Cs-134 6889 2.09749E-06 300 END
La-139 6889 0.000459683 300 END
Ce-141 6889 0.000190134 300 END
Pr-141 6889 0.000232471 300 END
Pr-143 6889 9.62257E-05 300 END
Nd-143 6889 0.000343775 300 END
Nd-145 6889 0.000287391 300 END
Nd-147 6889 2.53814E-05 300 END
Pm-147 6889 0.000287391 300 END
Pm-149 6889 5.02988E-07 300 END
Sm-149 6889 7.62397E-06 300 END
Sm-150 6889 7.62354E-05 300 END
Sm-151 6889 1.22149E-05 300 END
Sm-152 6889 4.25032E-05 300 END
Eu-153 6889 1.289E-05 300 END
Eu-154 6889 4.15012E-07 300 END
Eu-155 6889 1.61834E-06 300 END
Gd-155 6889 8.20392E-09 300 END
Gd-157 6889 2.14779E-08 300 END

' 5914   ρ= 6.2454 MWD= 5.372249322
h-zrh2 5914 0.100088539 300 END
u-235 5914 0.083942777 300 END
u-238 5914 0.399054778 300 END
zr-90 5914 2.912553605 300 END
zr-91 5914 0.635247564 300 END
zr-92 5914 0.971347095 300 END
zr-94 5914 0.984289728 300 END
zr-96 5914 0.15884606 300 END
U-236 5914 0.002165554 300 END
Pu-239 5914 0.000396659 300 END
Pu-240 5914 3.13247E-05 300 END
Pu-241 5914 3.58168E-08 300 END
Np-237 5914 4.15929E-06 300 END
Kr-83 5914 2.19618E-05 300 END
I-129 5914 3.66887E-05 300 END

I-131 5914 1.99397E-05 300 END
Xe-131 5914 0.000182098 300 END
Xe-133 5914 2.65498E-05 300 END
Xe-135 5914 3.04802E-11 300 END
Mo-95 5914 5.15325E-05 300 END
Mo-97 5914 0.000318574 300 END
Tc-99 5914 0.000325177 300 END
Ru-101 5914 0.000280775 300 END
Rh-103 5914 8.30442E-05 300 END
Rh-105 5914 6.89248E-08 300 END
Pd-105 5914 4.93602E-05 300 END
Cd-113 5914 7.38893E-08 300 END
Cs-133 5914 0.000457157 300 END
Cs-134 5914 2.26753E-06 300 END
La-139 5914 0.000476701 300 END
Ce-141 5914 0.000193239 300 END
Pr-141 5914 0.000244845 300 END
Pr-143 5914 9.68749E-05 300 END
Nd-143 5914 0.000356502 300 END
Nd-145 5914 0.000298031 300 END
Nd-147 5914 2.55014E-05 300 END
Pm-147 5914 0.000298031 300 END
Pm-149 5914 5.0426E-07 300 END
Sm-149 5914 7.62473E-06 300 END
Sm-150 5914 7.92195E-05 300 END
Sm-151 5914 1.23056E-05 300 END
Sm-152 5914 4.41799E-05 300 END
Eu-153 5914 1.34426E-05 300 END
Eu-154 5914 4.4941E-07 300 END
Eu-155 5914 1.65396E-06 300 END
Gd-155 5914 8.393E-09 300 END
Gd-157 5914 2.14848E-08 300 END

' 6142 ρ= 6.2451 MWD= 5.492858612
h-zrh2 6142 0.100088539 300 END
u-235 6142 0.083614201 300 END
u-238 6142 0.399042189 300 END
zr-90 6142 2.912551971 300 END
zr-91 6142 0.635249221 300 END
zr-92 6142 0.971356111 300 END
zr-94 6142 0.984296564 300 END
zr-96 6142 0.158853275 300 END
U-236 6142 0.002214171 300 END
Pu-239 6142 0.00040402 300 END
Pu-240 6142 3.27105E-05 300 END
Pu-241 6142 3.65816E-08 300 END
Np-237 6142 4.35148E-06 300 END
Kr-83 6142 2.24548E-05 300 END
I-129 6142 3.75124E-05 300 END
I-131 6142 1.99773E-05 300 END
Xe-131 6142 0.000186186 300 END
Xe-133 6142 2.65524E-05 300 END
Xe-135 6142 3.04464E-11 300 END
Mo-95 6142 5.40446E-05 300 END
Mo-97 6142 0.000325727 300 END
Tc-99 6142 0.000332477 300 END
Ru-101 6142 0.000287079 300 END
Rh-103 6142 8.5811E-05 300 END
Rh-105 6142 6.8925E-08 300 END
Pd-105 6142 5.04684E-05 300 END
Cd-113 6142 7.36793E-08 300 END
Cs-133 6142 0.00046742 300 END
Cs-134 6142 2.37845E-06 300 END
La-139 6142 0.000487403 300 END
Ce-141 6142 0.00019511 300 END

Pr-141 6142 0.000252708 300 END
Pr-143 6142 9.72533E-05 300 END
Nd-143 6142 0.000364506 300 END
Nd-145 6142 0.000304722 300 END
Nd-147 6142 2.55703E-05 300 END
Pm-147 6142 0.000304722 300 END
Pm-149 6142 5.0505E-07 300 END
Sm-149 6142 7.62471E-06 300 END
Sm-150 6142 8.1102E-05 300 END
Sm-151 6142 1.23579E-05 300 END
Sm-152 6142 4.52381E-05 300 END
Eu-153 6142 1.37928E-05 300 END
Eu-154 6142 4.71806E-07 300 END
Eu-155 6142 1.67603E-06 300 END
Gd-155 6142 8.5102E-09 300 END
Gd-157 6142 2.14889E-08 300 END

' 6928 ρ= 6.2772 MWD= 5.55501188
h-zrh2 6928 0.100605558 300 END
u-235 6928 0.083444877 300 END
u-238 6928 0.401565497 300 END
zr-90 6928 2.927596526 300 END
zr-91 6928 0.638531448 300 END
zr-92 6928 0.976376387 300 END
zr-94 6928 0.989382975 300 END
zr-96 6928 0.159675871 300 END
U-236 6928 0.002239225 300 END
Pu-239 6928 0.000407785 300 END
Pu-240 6928 3.3436E-05 300 END
Pu-241 6928 3.69751E-08 300 END
Np-237 6928 4.45237E-06 300 END
Kr-83 6928 2.27089E-05 300 END
I-129 6928 3.79368E-05 300 END
I-131 6928 1.99955E-05 300 END
Xe-131 6928 0.000188293 300 END
Xe-133 6928 2.65527E-05 300 END
Xe-135 6928 3.04289E-11 300 END
Mo-95 6928 5.53633E-05 300 END
Mo-97 6928 0.000329412 300 END
Tc-99 6928 0.000336239 300 END
Ru-101 6928 0.000290327 300 END
Rh-103 6928 8.72453E-05 300 END
Rh-105 6928 6.89246E-08 300 END
Pd-105 6928 5.10394E-05 300 END
Cd-113 6928 7.35695E-08 300 END
Cs-133 6928 0.000472709 300 END
Cs-134 6928 2.43682E-06 300 END
La-139 6928 0.000492918 300 END
Ce-141 6928 0.00019605 300 END
Pr-141 6928 0.000256784 300 END
Pr-143 6928 9.74398E-05 300 END
Nd-143 6928 0.000368631 300 END
Nd-145 6928 0.00030817 300 END
Nd-147 6928 2.5604E-05 300 END
Pm-147 6928 0.00030817 300 END
Pm-149 6928 5.05454E-07 300 END
Sm-149 6928 7.62457E-06 300 END
Sm-150 6928 8.20739E-05 300 END
Sm-151 6928 1.23834E-05 300 END
Sm-152 6928 4.57845E-05 300 END
Eu-153 6928 1.39741E-05 300 END
Eu-154 6928 4.83579E-07 300 END
Eu-155 6928 1.68731E-06 300 END
Gd-155 6928 8.57011E-09 300 END
Gd-157 6928 2.1491E-08 300 END

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' 10817   ρ= 5.6943 MWD= 1.419147872
  h-zrh2 10817 0.091099002  300 END
  u-235 10817 0.094634386  300 END
  u-238 10817 0.355512816  300 END
  zr-90 10817 2.650998569  300 END
  zr-91 10817 0.578165571  300 END
  zr-92 10817 0.883853515  300 END
  zr-94 10817 0.895688186  300 END
  zr-96 10817 0.144371535  300 END
  U-236 10817 0.000572059  300 END
  Pu-239 10817 0.000115074  300 END
  Pu-240 10817 2.29744E-06  300 END
  Pu-241 10817 9.84486E-09  300 END
  Np-237 10817 3.04476E-07  300 END
  Kr-83 10817 5.80148E-06  300 END
  I-129 10817 9.69179E-06  300 END
  I-131 10817 1.44464E-05  300 END
  Xe-131 10817 4.81034E-05  300 END
  Xe-133 10817 2.21984E-05  300 END
  Xe-135 10817 3.12893E-11  300 END
  Mo-95 10817 2.87522E-06  300 END
  Mo-97 10817 8.41555E-05  300 END
  Tc-99 10817 8.58996E-05  300 END
  Ru-101 10817 7.41703E-05  300 END
  Rh-103 10817 1.05148E-05  300 END
  Rh-105 10817 6.73787E-08  300 END
  Pd-105 10817 1.30391E-05  300 END
  Cd-113 10817 7.02085E-08  300 END
  Cs-133 10817 0.000120764  300 END
  Cs-134 10817 1.49127E-07  300 END
  La-139 10817 0.000125927  300 END
  Ce-141 10817 8.0798E-05  300 END
  Pr-141 10817 3.46741E-05  300 END
  Pr-143 10817 5.77608E-05  300 END
  Nd-143 10817 9.41747E-05  300 END
  Nd-145 10817 7.87286E-05  300 END
  Nd-147 10817 1.68063E-05  300 END
  Pm-147 10817 7.87286E-05  300 END
  Pm-149 10817 4.61997E-07  300 END
  Sm-149 10817 6.92753E-06  300 END
  Sm-150 10817 2.00465E-05  300 END
  Sm-151 10817 6.75293E-06  300 END
  Sm-152 10817 1.11089E-05  300 END
  Eu-153 10817 3.14081E-06  300 END
  Eu-154 10817 2.43394E-08  300 END
  Eu-155 10817 6.64826E-07  300 END
  Gd-155 10817 3.25519E-09  300 END
  Gd-157 10817 2.09743E-08  300 END

' 5911   ρ= 6.2816 MWD= 3.880316811
  h-zrh2 5911 0.100605558  300 END
  u-235 5911 0.088007249  300 END
  u-238 5911 0.401734491  300 END
  zr-90 5911 2.927617691  300 END
  zr-91 5911 0.638512115  300 END
  zr-92 5911 0.976252657  300 END
  zr-94 5911 0.989288046  300 END
  zr-96 5911 0.15957568  300 END
  U-236 5911 0.001564156  300 END
  Pu-239 5911 0.000299557  300 END
  Pu-240 5911 1.65993E-05  300 END
  Pu-241 5911 2.6226E-08  300 END
  Np-237 5911 2.16263E-06  300 END
  Kr-83 5911 1.58627E-05  300 END
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I-129 5911 2.64998E-05 300 END
I-131 5911 1.91607E-05 300 END
Xe-131 5911 0.000131527 300 END
Xe-133 5911 2.62422E-05 300 END
Xe-135 5911 3.08748E-11 300 END
Mo-95 5911 2.55668E-05 300 END
Mo-97 5911 0.000230103 300 END
Tc-99 5911 0.000234872 300 END
Ru-101 5911 0.000202801 300 END
Rh-103 5911 5.09382E-05 300 END
Rh-105 5911 6.87919E-08 300 END
Pd-105 5911 3.56524E-05 300 END
Cd-113 5911 7.59631E-08 300 END
Cs-133 5911 0.000330199 300 END
Cs-134 5911 1.13976E-06 300 END
La-139 5911 0.000344316 300 END
Ce-141 5911 0.000164181 300 END
Pr-141 5911 0.00015331 300 END
Pr-143 5911 8.9852E-05 300 END
Nd-143 5911 0.000257498 300 END
Nd-145 5911 0.000215264 300 END
Nd-147 5911 2.41307E-05 300 END
Pm-147 5911 0.000215264 300 END
Pm-149 5911 4.93626E-07 300 END
Sm-149 5911 7.58321E-06 300 END
Sm-150 5911 5.63109E-05 300 END
Sm-151 5911 1.1293E-05 300 END
Sm-152 5911 3.1331E-05 300 END
Eu-153 5911 9.28611E-06 300 END
Eu-154 5911 2.20376E-07 300 END
Eu-155 5911 1.35506E-06 300 END
Gd-155 5911 6.81294E-09 300 END
Gd-157 5911 2.14129E-08 300 END

' 3496 ρ= 6.3119 MWD= 4.759375885
h-zrh2 3496 0.101127855 300 END
u-235 3496 0.085612428 300 END
u-238 3496 0.404203135 300 END
zr-90 3496 2.942806037 300 END
zr-91 3496 0.641836033 300 END
zr-92 3496 0.981384004 300 END
zr-94 3496 0.994472655 300 END
zr-96 3496 0.160455508 300 END
U-236 3496 0.001918504 300 END
Pu-239 3496 0.000358132 300 END
Pu-240 3496 2.47327E-05 300 END
Pu-241 3496 3.19064E-08 300 END
Np-237 3496 3.25499E-06 300 END
Kr-83 3496 1.94563E-05 300 END
I-129 3496 3.25032E-05 300 END
I-131 3496 1.96994E-05 300 END
Xe-131 3496 0.000161324 300 END
Xe-133 3496 2.64944E-05 300 END
Xe-135 3496 3.06481E-11 300 END
Mo-95 3496 3.97227E-05 300 END
Mo-97 3496 0.000282231 300 END
Tc-99 3496 0.00028808 300 END
Ru-101 3496 0.000248744 300 END
Rh-103 3496 6.93503E-05 300 END
Rh-105 3496 6.89025E-08 300 END
Pd-105 3496 4.37291E-05 300 END
Cd-113 3496 7.48834E-08 300 END
Cs-133 3496 0.000405004 300 END
Cs-134 3496 1.75084E-06 300 END
La-139 3496 0.000422318 300 END

Ce-141 3496 0.000182718 300 END
Pr-141 3496 0.000205893 300 END
Pr-143 3496 9.45725E-05 300 END
Nd-143 3496 0.000315832 300 END
Nd-145 3496 0.000264031 300 END
Nd-147 3496 2.50683E-05 300 END
Pm-147 3496 0.000264031 300 END
Pm-149 3496 5.00118E-07 300 END
Sm-149 3496 7.61843E-06 300 END
Sm-150 3496 6.97243E-05 300 END
Sm-151 3496 1.19799E-05 300 END
Sm-152 3496 3.88477E-05 300 END
Eu-153 3496 1.16957E-05 300 END
Eu-154 3496 3.44679E-07 300 END
Eu-155 3496 1.53757E-06 300 END
Gd-155 3496 7.77592E-09 300 END
Gd-157 3496 2.14607E-08 300 END

' 3504   ρ= 6.3119 MWD= 4.754157776
h-zrh2 3504 0.101127855 300 END
u-235 3504 0.085626644 300 END
u-238 3504 0.404203663 300 END
zr-90 3504 2.942806103 300 END
zr-91 3504 0.641835972 300 END
zr-92 3504 0.981383618 300 END
zr-94 3504 0.994472359 300 END
zr-96 3504 0.160455196 300 END
U-236 3504 0.001916401 300 END
Pu-239 3504 0.000357796 300 END
Pu-240 3504 2.46799E-05 300 END
Pu-241 3504 3.18729E-08 300 END
Np-237 3504 3.2478E-06 300 END
Kr-83 3504 1.9435E-05 300 END
I-129 3504 3.24676E-05 300 END
I-131 3504 1.96969E-05 300 END
Xe-131 3504 0.000161147 300 END
Xe-133 3504 2.64936E-05 300 END
Xe-135 3504 3.06495E-11 300 END
Mo-95 3504 3.9629E-05 300 END
Mo-97 3504 0.000281922 300 END
Tc-99 3504 0.000287764 300 END
Ru-101 3504 0.000248471 300 END
Rh-103 3504 6.92365E-05 300 END
Rh-105 3504 6.89021E-08 300 END
Pd-105 3504 4.36812E-05 300 END
Cd-113 3504 7.48912E-08 300 END
Cs-133 3504 0.00040456 300 END
Cs-134 3504 1.74677E-06 300 END
La-139 3504 0.000421855 300 END
Ce-141 3504 0.00018262 300 END
Pr-141 3504 0.000205569 300 END
Pr-143 3504 9.45498E-05 300 END
Nd-143 3504 0.000315486 300 END
Nd-145 3504 0.000263742 300 END
Nd-147 3504 2.50639E-05 300 END
Pm-147 3504 0.000263742 300 END
Pm-149 3504 5.00082E-07 300 END
Sm-149 3504 7.61832E-06 300 END
Sm-150 3504 6.9644E-05 300 END
Sm-151 3504 1.19767E-05 300 END
Sm-152 3504 3.88026E-05 300 END
Eu-153 3504 1.16811E-05 300 END
Eu-154 3504 3.43852E-07 300 END
Eu-155 3504 1.53655E-06 300 END
Gd-155 3504 7.77049E-09 300 END

Gd-157 3504 2.14604E-08 300 END

' 3703 ρ= 6.1488 MWD= 4.724361784
h-zrh2 3703 0.098517736 300 END
u-235 3703 0.083113649 300 END
u-238 3703 0.39380877 300 END
zr-90 3703 2.866851225 300 END
zr-91 3703 0.625270012 300 END
zr-92 3703 0.956060537 300 END
zr-94 3703 0.968810211 300 END
zr-96 3703 0.156319392 300 END
U-236 3703 0.00190439 300 END
Pu-239 3703 0.000355874 300 END
Pu-240 3703 2.43789E-05 300 END
Pu-241 3703 3.16818E-08 300 END
Np-237 3703 3.20692E-06 300 END
Kr-83 3703 1.93132E-05 300 END
I-129 3703 3.22641E-05 300 END
I-131 3703 1.96828E-05 300 END
Xe-131 3703 0.000160137 300 END
Xe-133 3703 2.64888E-05 300 END
Xe-135 3703 3.06575E-11 300 END
Mo-95 3703 3.90962E-05 300 END
Mo-97 3703 0.000280155 300 END
Tc-99 3703 0.000285961 300 END
Ru-101 3703 0.000246914 300 END
Rh-103 3703 6.85877E-05 300 END
Rh-105 3703 6.89E-08 300 END
Pd-105 3703 4.34074E-05 300 END
Cd-113 3703 7.49356E-08 300 END
Cs-133 3703 0.000402024 300 END
Cs-134 3703 1.72363E-06 300 END
La-139 3703 0.000419212 300 END
Ce-141 3703 0.000182062 300 END
Pr-141 3703 0.000203721 300 END
Pr-143 3703 9.44195E-05 300 END
Nd-143 3703 0.000313509 300 END
Nd-145 3703 0.000262089 300 END
Nd-147 3703 2.50388E-05 300 END
Pm-147 3703 0.000262089 300 END
Pm-149 3703 4.99874E-07 300 END
Sm-149 3703 7.61769E-06 300 END
Sm-150 3703 6.91854E-05 300 END
Sm-151 3703 1.1958E-05 300 END
Sm-152 3703 3.85454E-05 300 END
Eu-153 3703 1.15976E-05 300 END
Eu-154 3703 3.39149E-07 300 END
Eu-155 3703 1.53068E-06 300 END
Gd-155 3703 7.73946E-09 300 END
Gd-157 3703 2.14591E-08 300 END

' 10816 ρ= 5.9771 MWD= 1.617678246
h-zrh2 10816 0.095635096 300 END
u-235 10816 0.094145413 300 END
u-238 10816 0.37764395 300 END
zr-90 10816 2.782998616 300 END
zr-91 10816 0.606954878 300 END
zr-92 10816 0.927872263 300 END
zr-94 10816 0.94029445 300 END
zr-96 10816 0.151567879 300 END
U-236 10816 0.000652086 300 END
Pu-239 10816 0.000130992 300 END
Pu-240 10816 2.97723E-06 300 END
Pu-241 10816 1.11944E-08 300 END
Np-237 10816 3.91625E-07 300 END

Kr-83 10816 6.61307E-06 300 END
I-129 10816 1.10476E-05 300 END
I-131 10816 1.52087E-05 300 END
Xe-131 10816 5.48328E-05 300 END
Xe-133 10816 2.29697E-05 300 END
Xe-135 10816 3.12818E-11 300 END
Mo-95 10816 3.82362E-06 300 END
Mo-97 10816 9.59283E-05 300 END
Tc-99 10816 9.79164E-05 300 END
Ru-101 10816 8.45463E-05 300 END
Rh-103 10816 1.2961E-05 300 END
Rh-105 10816 6.76176E-08 300 END
Pd-105 10816 1.48632E-05 300 END
Cd-113 10816 7.19562E-08 300 END
Cs-133 10816 0.000137658 300 END
Cs-134 10816 1.93306E-07 300 END
La-139 10816 0.000143543 300 END
Ce-141 10816 8.97983E-05 300 END
Pr-141 10816 4.21696E-05 300 END
Pr-143 10816 6.22278E-05 300 END
Nd-143 10816 0.000107349 300 END
Nd-145 10816 8.97423E-05 300 END
Nd-147 10816 1.79087E-05 300 END
Pm-147 10816 8.97423E-05 300 END
Pm-149 10816 4.66664E-07 300 END
Sm-149 10816 7.06151E-06 300 END
Sm-150 10816 2.29012E-05 300 END
Sm-151 10816 7.35314E-06 300 END
Sm-152 10816 1.26952E-05 300 END
Eu-153 10816 3.60368E-06 300 END
Eu-154 10816 3.2424E-08 300 END
Eu-155 10816 7.36051E-07 300 END
Gd-155 10816 3.61464E-09 300 END
Gd-157 10816 2.10577E-08 300 END

' 2915 ρ= 6.351 MWD= 4.259843916
h-zrh2 2915 0.101729639 300 END
u-235 2915 0.089671238 300 END
u-238 2915 0.40472902 300 END
zr-90 2915 2.960324339 300 END
zr-91 2915 0.64564992 300 END
zr-92 2915 0.987185166 300 END
zr-94 2915 1.000360574 300 END
zr-96 2915 0.161378757 300 END
U-236 2915 0.001717143 300 END
Pu-239 2915 0.000325328 300 END
Pu-240 2915 1.99188E-05 300 END
Pu-241 2915 2.8689E-08 300 END
Np-237 2915 2.60526E-06 300 END
Kr-83 2915 1.74142E-05 300 END
I-129 2915 2.90918E-05 300 END
I-131 2915 1.94274E-05 300 END
Xe-131 2915 0.000144392 300 END
Xe-133 2915 2.63822E-05 300 END
Xe-135 2915 3.07794E-11 300 END
Mo-95 2915 3.12773E-05 300 END
Mo-97 2915 0.000252609 300 END
Tc-99 2915 0.000257844 300 END
Ru-101 2915 0.000222636 300 END
Rh-103 2915 5.86921E-05 300 END
Rh-105 2915 6.88529E-08 300 END
Pd-105 2915 3.91394E-05 300 END
Cd-113 2915 7.55637E-08 300 END
Cs-133 2915 0.000362496 300 END
Cs-134 2915 1.38546E-06 300 END

La-139 2915 0.000377993 300 END
Ce-141 2915 0.000172734 300 END
Pr-141 2915 0.000175498 300 END
Pr-143 2915 9.21318E-05 300 END
Nd-143 2915 0.000282683 300 END
Nd-145 2915 0.000236319 300 END
Nd-147 2915 2.45903E-05 300 END
Pm-147 2915 0.000236319 300 END
Pm-149 2915 4.96531E-07 300 END
Sm-149 2915 7.60316E-06 300 END
Sm-150 2915 6.20723E-05 300 END
Sm-151 2915 1.16265E-05 300 END
Sm-152 2915 3.45573E-05 300 END
Eu-153 2915 1.03126E-05 300 END
Eu-154 2915 2.70354E-07 300 END
Eu-155 2915 1.43647E-06 300 END
Gd-155 2915 7.24165E-09 300 END
Gd-157 2915 2.14359E-08 300 END

' 2946   ρ= 6.3112 MWD= 3.908545095
h-zrh2 2946 0.101078194 300 END
u-235 2946 0.089979739 300 END
u-238 2946 0.40216922 300 END
zr-90 2946 2.941371245 300 END
zr-91 2946 0.641512047 300 END
zr-92 2946 0.980839786 300 END
zr-94 2946 0.99393621 300 END
zr-96 2946 0.160325952 300 END
U-236 2946 0.001575535 300 END
Pu-239 2946 0.000301499 300 END
Pu-240 2946 1.68361E-05 300 END
Pu-241 2946 2.64098E-08 300 END
Np-237 2946 2.19406E-06 300 END
Kr-83 2946 1.59781E-05 300 END
I-129 2946 2.66926E-05 300 END
I-131 2946 1.91827E-05 300 END
Xe-131 2946 0.000132484 300 END
Xe-133 2946 2.62546E-05 300 END
Xe-135 2946 3.08679E-11 300 END
Mo-95 2946 2.59707E-05 300 END
Mo-97 2946 0.000231777 300 END
Tc-99 2946 0.00023658 300 END
Ru-101 2946 0.000204276 300 END
Rh-103 2946 5.15039E-05 300 END
Rh-105 2946 6.87972E-08 300 END
Pd-105 2946 3.59117E-05 300 END
Cd-113 2946 7.59378E-08 300 END
Cs-133 2946 0.000332602 300 END
Cs-134 2946 1.15711E-06 300 END
La-139 2946 0.000346821 300 END
Ce-141 2946 0.000164848 300 END
Pr-141 2946 0.000154932 300 END
Pr-143 2946 9.0036E-05 300 END
Nd-143 2946 0.000259371 300 END
Nd-145 2946 0.00021683 300 END
Nd-147 2946 2.41682E-05 300 END
Pm-147 2946 0.00021683 300 END
Pm-149 2946 4.93848E-07 300 END
Sm-149 2946 7.58499E-06 300 END
Sm-150 2946 5.67379E-05 300 END
Sm-151 2946 1.132E-05 300 END
Sm-152 2946 3.157E-05 300 END
Eu-153 2946 9.36173E-06 300 END
Eu-154 2946 2.23902E-07 300 END
Eu-155 2946 1.36127E-06 300 END

Gd-155 2946 6.84559E-09 300 END
Gd-157 2946 2.14147E-08 300 END

' 6924 ρ= 6.2774 MWD= 5.470193857
h-zrh2 6924 0.100605558 300 END
u-235 6924 0.083675947 300 END
u-238 6924 0.401574383 300 END
zr-90 6924 2.927597684 300 END
zr-91 6924 0.638530264 300 END
zr-92 6924 0.976370038 300 END
zr-94 6924 0.989378167 300 END
zr-96 6924 0.159670796 300 END
U-236 6924 0.002205035 300 END
Pu-239 6924 0.000402642 300 END
Pu-240 6924 3.24479E-05 300 END
Pu-241 6924 3.6438E-08 300 END
Np-237 6924 4.315E-06 300 END
Kr-83 6924 2.23622E-05 300 END
I-129 6924 3.73576E-05 300 END
I-131 6924 1.99704E-05 300 END
Xe-131 6924 0.000185418 300 END
Xe-133 6924 2.65521E-05 300 END
Xe-135 6924 3.04528E-11 300 END
Mo-95 6924 5.35678E-05 300 END
Mo-97 6924 0.000324382 300 END
Tc-99 6924 0.000331105 300 END
Ru-101 6924 0.000285894 300 END
Rh-103 6924 8.52893E-05 300 END
Rh-105 6924 6.89251E-08 300 END
Pd-105 6924 5.02601E-05 300 END
Cd-113 6924 7.3719E-08 300 END
Cs-133 6924 0.000465492 300 END
Cs-134 6924 2.35737E-06 300 END
La-139 6924 0.000485392 300 END
Ce-141 6924 0.000194763 300 END
Pr-141 6924 0.000251226 300 END
Pr-143 6924 9.71839E-05 300 END
Nd-143 6924 0.000363002 300 END
Nd-145 6924 0.000303464 300 END
Nd-147 6924 2.55577E-05 300 END
Pm-147 6924 0.000303464 300 END
Pm-149 6924 5.04902E-07 300 END
Sm-149 6924 7.62474E-06 300 END
Sm-150 6924 8.07479E-05 300 END
Sm-151 6924 1.23483E-05 300 END
Sm-152 6924 4.5039E-05 300 END
Eu-153 6924 1.37268E-05 300 END
Eu-154 6924 4.67552E-07 300 END
Eu-155 6924 1.6719E-06 300 END
Gd-155 6924 8.48828E-09 300 END
Gd-157 6924 2.14882E-08 300 END

' 10812 ρ= 6.2493 MWD= 1.722912183
h-zrh2 10812 0.099997928 300 END
u-235 10812 0.093339891 300 END
u-238 10812 0.399457391 300 END
zr-90 10812 2.909957471 300 END
zr-91 10812 0.634644546 300 END
zr-92 10812 0.970203684 300 END
zr-94 10812 0.983192064 300 END
zr-96 10812 0.158484222 300 END
U-236 10812 0.000694506 300 END
Pu-239 10812 0.000139366 300 END
Pu-240 10812 3.37201E-06 300 END
Pu-241 10812 1.19075E-08 300 END

Np-237 10812 4.4219E-07 300 END
Kr-83 10812 7.04327E-06 300 END
I-129 10812 1.17663E-05 300 END
I-131 10812 1.55645E-05 300 END
Xe-131 10812 5.83998E-05 300 END
Xe-133 10812 2.33174E-05 300 END
Xe-135 10812 3.12745E-11 300 END
Mo-95 10812 4.38583E-06 300 END
Mo-97 10812 0.000102169 300 END
Tc-99 10812 0.000104286 300 END
Ru-101 10812 9.00463E-05 300 END
Rh-103 10812 1.43296E-05 300 END
Rh-105 10812 6.77284E-08 300 END
Pd-105 10812 1.58301E-05 300 END
Cd-113 10812 7.26983E-08 300 END
Cs-133 10812 0.000146613 300 END
Cs-134 10812 2.19113E-07 300 END
La-139 10812 0.000152881 300 END
Ce-141 10812 9.43741E-05 300 END
Pr-141 10812 4.6327E-05 300 END
Pr-143 10812 6.43896E-05 300 END
Nd-143 10812 0.000114332 300 END
Nd-145 10812 9.55803E-05 300 END
Nd-147 10812 1.84329E-05 300 END
Pm-147 10812 9.55803E-05 300 END
Pm-149 10812 4.68808E-07 300 END
Sm-149 10812 7.12055E-06 300 END
Sm-150 10812 2.44195E-05 300 END
Sm-151 10812 7.64779E-06 300 END
Sm-152 10812 1.35392E-05 300 END
Eu-153 10812 3.85137E-06 300 END
Eu-154 10812 3.72237E-08 300 END
Eu-155 10812 7.72277E-07 300 END
Gd-155 10812 3.79822E-09 300 END
Gd-157 10812 2.10944E-08 300 END

' 2958 ρ= 6.3887 MWD= 3.578637141
h-zrh2 2958 0.102302911 300 END
u-235 2958 0.092097767 300 END
u-238 2958 0.407077986 300 END
zr-90 2958 2.977014632 300 END
zr-91 2958 0.649282166 300 END
zr-92 2958 0.992696836 300 END
zr-94 2958 1.005957878 300 END
zr-96 2958 0.162245975 300 END
U-236 2958 0.001442549 300 END
Pu-239 2958 0.000278549 300 END
Pu-240 2958 1.417E-05 300 END
Pu-241 2958 2.42567E-08 300 END
Np-237 2958 1.84155E-06 300 END
Kr-83 2958 1.46295E-05 300 END
I-129 2958 2.44396E-05 300 END
I-131 2958 1.89022E-05 300 END
Xe-131 2958 0.000121301 300 END
Xe-133 2958 2.60873E-05 300 END
Xe-135 2958 3.09474E-11 300 END
Mo-95 2958 2.14597E-05 300 END
Mo-97 2958 0.000212213 300 END
Tc-99 2958 0.000216611 300 END
Ru-101 2958 0.000187034 300 END
Rh-103 2958 4.50092E-05 300 END
Rh-105 2958 6.8726E-08 300 END
Pd-105 2958 3.28805E-05 300 END
Cd-113 2958 7.618E-08 300 END
Cs-133 2958 0.000304528 300 END

Cs-134 2958 9.63383E-07 300 END
La-139 2958 0.000317547 300 END
Ce-141 2958 0.000156718 300 END
Pr-141 2958 0.000136283 300 END
Pr-143 2958 8.77226E-05 300 END
Nd-143 2958 0.000237478 300 END
Nd-145 2958 0.000198528 300 END
Nd-147 2958 2.36918E-05 300 END
Pm-147 2958 0.000198528 300 END
Pm-149 2958 4.91166E-07 300 END
Sm-149 2958 7.5606E-06 300 END
Sm-150 2958 5.17635E-05 300 END
Sm-151 2958 1.09803E-05 300 END
Sm-152 2958 2.8787E-05 300 END
Eu-153 2958 8.48521E-06 300 END
Eu-154 2958 1.84575E-07 300 END
Eu-155 2958 1.28702E-06 300 END
Gd-155 2958 6.4558E-09 300 END
Gd-157 2958 2.13911E-08 300 END

' 5913 ρ= 6.2458 MWD= 5.202096418
h-zrh2 5913 0.100088539 300 END
u-235 5913 0.084406324 300 END
u-238 5913 0.399072419 300 END
zr-90 5913 2.91255588 300 END
zr-91 5913 0.6352453 300 END
zr-92 5913 0.971334405 300 END
zr-94 5913 0.984280083 300 END
zr-96 5913 0.15883588 300 END
U-236 5913 0.002096965 300 END
Pu-239 5913 0.000386151 300 END
Pu-240 5913 2.94191E-05 300 END
Pu-241 5913 3.47352E-08 300 END
Np-237 5913 3.89617E-06 300 END
Kr-83 5913 2.12662E-05 300 END
I-129 5913 3.55267E-05 300 END
I-131 5913 1.98817E-05 300 END
Xe-131 5913 0.00017633 300 END
Xe-133 5913 2.6542E-05 300 END
Xe-135 5913 3.05275E-11 300 END
Mo-95 5913 4.80936E-05 300 END
Mo-97 5913 0.000308484 300 END
Tc-99 5913 0.000314878 300 END
Ru-101 5913 0.000271882 300 END
Rh-103 5913 7.91796E-05 300 END
Rh-105 5913 6.89223E-08 300 END
Pd-105 5913 4.77969E-05 300 END
Cd-113 5913 7.41787E-08 300 END
Cs-133 5913 0.000442678 300 END
Cs-134 5913 2.11629E-06 300 END
La-139 5913 0.000461603 300 END
Ce-141 5913 0.000190493 300 END
Pr-141 5913 0.000233859 300 END
Pr-143 5913 9.6302E-05 300 END
Nd-143 5913 0.000345211 300 END
Nd-145 5913 0.000288592 300 END
Nd-147 5913 2.53956E-05 300 END
Pm-147 5913 0.000288592 300 END
Pm-149 5913 5.03133E-07 300 END
Sm-149 5913 7.62411E-06 300 END
Sm-150 5913 7.65716E-05 300 END
Sm-151 5913 1.22256E-05 300 END
Sm-152 5913 4.2692E-05 300 END
Eu-153 5913 1.29521E-05 300 END
Eu-154 5913 4.18819E-07 300 END

Eu-155 5913 1.62239E-06 300 END
Gd-155 5913 8.22543E-09 300 END
Gd-157 5913 2.14787E-08 300 END

' 2902   ρ= 6.3518 MWD= 3.970959647
h-zrh2 2902 0.101729639 300 END
u-235 2902 0.090458245 300 END
u-238 2902 0.404757326 300 END
zr-90 2902 2.960327768 300 END
zr-91 2902 0.645647133 300 END
zr-92 2902 0.987164035 300 END
zr-94 2902 1.000344199 300 END
zr-96 2902 0.161361474 300 END
U-236 2902 0.001600694 300 END
Pu-239 2902 0.000305779 300 END
Pu-240 2902 1.73655E-05 300 END
Pu-241 2902 2.68157E-08 300 END
Np-237 2902 2.2644E-06 300 END
Kr-83 2902 1.62333E-05 300 END
I-129 2902 2.71189E-05 300 END
I-131 2902 1.92299E-05 300 END
Xe-131 2902 0.0001346 300 END
Xe-133 2902 2.62807E-05 300 END
Xe-135 2902 3.08524E-11 300 END
Mo-95 2902 2.68755E-05 300 END
Mo-97 2902 0.000235478 300 END
Tc-99 2902 0.000240358 300 END
Ru-101 2902 0.000207538 300 END
Rh-103 2902 5.27612E-05 300 END
Rh-105 2902 6.88085E-08 300 END
Pd-105 2902 3.64852E-05 300 END
Cd-113 2902 7.58792E-08 300 END
Cs-133 2902 0.000337913 300 END
Cs-134 2902 1.196E-06 300 END
La-139 2902 0.000352359 300 END
Ce-141 2902 0.000166305 300 END
Pr-141 2902 0.000158534 300 END
Pr-143 2902 9.04343E-05 300 END
Nd-143 2902 0.000263513 300 END
Nd-145 2902 0.000220293 300 END
Nd-147 2902 2.42491E-05 300 END
Pm-147 2902 0.000220293 300 END
Pm-149 2902 4.94337E-07 300 END
Sm-149 2902 7.58875E-06 300 END
Sm-150 2902 5.76828E-05 300 END
Sm-151 2902 1.13783E-05 300 END
Sm-152 2902 3.20989E-05 300 END
Eu-153 2902 9.52935E-06 300 END
Eu-154 2902 2.31809E-07 300 END
Eu-155 2902 1.37491E-06 300 END
Gd-155 2902 6.91731E-09 300 END
Gd-157 2902 2.14188E-08 300 END

' 10813   ρ= 6.2696 MWD= 1.538987856
h-zrh2 10813 0.100315466 300 END
u-235 10813 0.094152256 300 END
u-238 10813 0.400742097 300 END
zr-90 10813 2.919199516 300 END
zr-91 10813 0.636659671 300 END
zr-92 10813 0.973271238 300 END
zr-94 10813 0.986303399 300 END
zr-96 10813 0.158976148 300 END
U-236 10813 0.000620366 300 END
Pu-239 10813 0.000124701 300 END
Pu-240 10813 2.69759E-06 300 END

Pu-241 10813 1.06601E-08 300 END
Np-237 10813 3.55793E-07 300 END
Kr-83 10813 6.29138E-06 300 END
I-129 10813 1.05102E-05 300 END
I-131 10813 1.49218E-05 300 END
Xe-131 10813 5.21655E-05 300 END
Xe-133 10813 2.26836E-05 300 END
Xe-135 10813 3.12858E-11 300 END
Mo-95 10813 3.43027E-06 300 END
Mo-97 10813 9.1262E-05 300 END
Tc-99 10813 9.31534E-05 300 END
Ru-101 10813 8.04337E-05 300 END
Rh-103 10813 1.19697E-05 300 END
Rh-105 10813 6.7528E-08 300 END
Pd-105 10813 1.41402E-05 300 END
Cd-113 10813 7.13228E-08 300 END
Cs-133 10813 0.000130962 300 END
Cs-134 10813 1.75093E-07 300 END
La-139 10813 0.000136561 300 END
Ce-141 10813 8.62893E-05 300 END
Pr-141 10813 3.91429E-05 300 END
Pr-143 10813 6.0521E-05 300 END
Nd-143 10813 0.000102127 300 END
Nd-145 10813 8.53769E-05 300 END
Nd-147 10813 1.74906E-05 300 END
Pm-147 10813 8.53769E-05 300 END
Pm-149 10813 4.64923E-07 300 END
Sm-149 10813 7.0123E-06 300 END
Sm-150 10813 2.17682E-05 300 END
Sm-151 10813 7.12241E-06 300 END
Sm-152 10813 1.20655E-05 300 END
Eu-153 10813 3.41953E-06 300 END
Eu-154 10813 2.90689E-08 300 END
Eu-155 10813 7.08285E-07 300 END
Gd-155 10813 3.47428E-09 300 END
Gd-157 10813 2.10272E-08 300 END

' 2912   ρ= 6.3366 MWD= 4.182766325
h-zrh2 2912 0.101495119 300 END
u-235 2912 0.089647745 300 END
u-238 2912 0.403802711 300 END
zr-90 2912 2.953500655 300 END
zr-91 2912 0.644160723 300 END
zr-92 2912 0.984904427 300 END
zr-94 2912 0.998050603 300 END
zr-96 2912 0.161002702 300 END
U-236 2912 0.001686073 300 END
Pu-239 2912 0.000320154 300 END
Pu-240 2912 1.9221E-05 300 END
Pu-241 2912 2.81901E-08 300 END
Np-237 2912 2.51184E-06 300 END
Kr-83 2912 1.70991E-05 300 END
I-129 2912 2.85654E-05 300 END
I-131 2912 1.93779E-05 300 END
Xe-131 2912 0.000141779 300 END
Xe-133 2912 2.63581E-05 300 END
Xe-135 2912 3.07991E-11 300 END
Mo-95 2912 3.00684E-05 300 END
Mo-97 2912 0.000248038 300 END
Tc-99 2912 0.000253179 300 END
Ru-101 2912 0.000218608 300 END
Rh-103 2912 5.70922E-05 300 END
Rh-105 2912 6.88423E-08 300 END
Pd-105 2912 3.84313E-05 300 END
Cd-113 2912 7.56544E-08 300 END

Cs-133 2912 0.000355937 300 END
Cs-134 2912 1.33337E-06 300 END
La-139 2912 0.000371154 300 END
Ce-141 2912 0.000171068 300 END
Pr-141 2912 0.000170926 300 END
Pr-143 2912 9.17013E-05 300 END
Nd-143 2912 0.000277568 300 END
Nd-145 2912 0.000232043 300 END
Nd-147 2912 2.45044E-05 300 END
Pm-147 2912 0.000232043 300 END
Pm-149 2912 4.95955E-07 300 END
Sm-149 2912 7.59977E-06 300 END
Sm-150 2912 6.08986E-05 300 END
Sm-151 2912 1.15637E-05 300 END
Sm-152 2912 3.38997E-05 300 END
Eu-153 2912 1.01024E-05 300 END
Eu-154 2912 2.59754E-07 300 END
Eu-155 2912 1.42028E-06 300 END
Gd-155 2912 7.1563E-09 300 END
Gd-157 2912 2.14316E-08 300 END

' 6143   ρ= 6.2469 MWD= 4.786938559
h-zrh2 6143 0.100088539 300 END
u-235 6143 0.085537339 300 END
u-238 6143 0.399114871 300 END
zr-90 6143 2.912561274 300 END
zr-91 6143 0.635240141 300 END
zr-92 6143 0.971303591 300 END
zr-94 6143 0.98425655 300 END
zr-96 6143 0.158811043 300 END
U-236 6143 0.001929615 300 END
Pu-239 6143 0.000359905 300 END
Pu-240 6143 2.5013E-05 300 END
Pu-241 6143 3.20831E-08 300 END
Np-237 6143 3.2931E-06 300 END
Kr-83 6143 1.9569E-05 300 END
I-129 6143 3.26914E-05 300 END
I-131 6143 1.97122E-05 300 END
Xe-131 6143 0.000162258 300 END
Xe-133 6143 2.64987E-05 300 END
Xe-135 6143 3.06407E-11 300 END
Mo-95 6143 4.02195E-05 300 END
Mo-97 6143 0.000283865 300 END
Tc-99 6143 0.000289749 300 END
Ru-101 6143 0.000250185 300 END
Rh-103 6143 6.99523E-05 300 END
Rh-105 6143 6.89043E-08 300 END
Pd-105 6143 4.39824E-05 300 END
Cd-113 6143 7.48419E-08 300 END
Cs-133 6143 0.000407349 300 END
Cs-134 6143 1.77243E-06 300 END
La-139 6143 0.000424764 300 END
Ce-141 6143 0.00018323 300 END
Pr-141 6143 0.000207607 300 END
Pr-143 6143 9.46911E-05 300 END
Nd-143 6143 0.000317661 300 END
Nd-145 6143 0.00026556 300 END
Nd-147 6143 2.50911E-05 300 END
Pm-147 6143 0.00026556 300 END
Pm-149 6143 5.0031E-07 300 END
Sm-149 6143 7.61897E-06 300 END
Sm-150 6143 7.01488E-05 300 END
Sm-151 6143 1.1997E-05 300 END
Sm-152 6143 3.90859E-05 300 END
Eu-153 6143 1.17731E-05 300 END

Eu-154 6143 3.49066E-07 300 END
Eu-155 6143 1.54297E-06 300 END
Gd-155 6143 7.80452E-09 300 END
Gd-157 6143 2.14619E-08 300 END

' 5916   ρ= 6.2468 MWD= 4.844601027
h-zrh2 5916 0.100088539 300 END
u-235 5916 0.085380249 300 END
u-238 5916 0.399109025 300 END
zr-90 5916 2.912560538 300 END
zr-91 5916 0.635240826 300 END
zr-92 5916 0.971307859 300 END
zr-94 5916 0.984259819 300 END
zr-96 5916 0.158814492 300 END
U-236 5916 0.001952859 300 END
Pu-239 5916 0.000363602 300 END
Pu-240 5916 2.56043E-05 300 END
Pu-241 5916 3.24526E-08 300 END
Np-237 5916 3.3736E-06 300 END
Kr-83 5916 1.98047E-05 300 END
I-129 5916 3.30852E-05 300 END
I-131 5916 1.97383E-05 300 END
Xe-131 5916 0.000164213 300 END
Xe-133 5916 2.65069E-05 300 END
Xe-135 5916 3.06252E-11 300 END
Mo-95 5916 4.12693E-05 300 END
Mo-97 5916 0.000287285 300 END
Tc-99 5916 0.000293239 300 END
Ru-101 5916 0.000253198 300 END
Rh-103 5916 7.12159E-05 300 END
Rh-105 5916 6.89079E-08 300 END
Pd-105 5916 4.45122E-05 300 END
Cd-113 5916 7.4754E-08 300 END
Cs-133 5916 0.000412256 300 END
Cs-134 5916 1.81809E-06 300 END
La-139 5916 0.000429881 300 END
Ce-141 5916 0.000184289 300 END
Pr-141 5916 0.000211204 300 END
Pr-143 5916 9.49343E-05 300 END
Nd-143 5916 0.000321488 300 END
Nd-145 5916 0.000268759 300 END
Nd-147 5916 2.51376E-05 300 END
Pm-147 5916 0.000268759 300 END
Pm-149 5916 5.00709E-07 300 END
Sm-149 5916 7.62003E-06 300 END
Sm-150 5916 7.10377E-05 300 END
Sm-151 5916 1.20318E-05 300 END
Sm-152 5916 3.95847E-05 300 END
Eu-153 5916 1.19354E-05 300 END
Eu-154 5916 3.58342E-07 300 END
Eu-155 5916 1.55422E-06 300 END
Gd-155 5916 7.86407E-09 300 END
Gd-157 5916 2.14644E-08 300 END

' 2940   ρ= 6.4125 MWD= 3.797480695
h-zrh2 2940 0.102693778 300 END
u-235 2940 0.091890696 300 END
u-238 2940 0.408613498 300 END
zr-90 2940 2.988386504 300 END
zr-91 2940 0.651764679 300 END
zr-92 2940 0.996504547 300 END
zr-94 2940 1.009812953 300 END
zr-96 2940 0.16287814 300 END
U-236 2940 0.001530764 300 END
Pu-239 2940 0.000293835 300 END

Pu-240 2940 1.59138E-05 300 END
Pu-241 2940 2.56863E-08 300 END
Np-237 2940 2.07178E-06 300 END
Kr-83 2940 1.55241E-05 300 END
I-129 2940 2.59341E-05 300 END
I-131 2940 1.90943E-05 300 END
Xe-131 2940 0.000128719 300 END
Xe-133 2940 2.6204E-05 300 END
Xe-135 2940 3.08951E-11 300 END
Mo-95 2940 2.44011E-05 300 END
Mo-97 2940 0.000225191 300 END
Tc-99 2940 0.000229858 300 END
Ru-101 2940 0.000198472 300 END
Rh-103 2940 4.92886E-05 300 END
Rh-105 2940 6.87754E-08 300 END
Pd-105 2940 3.48913E-05 300 END
Cd-113 2940 7.60327E-08 300 END
Cs-133 2940 0.00032315 300 END
Cs-134 2940 1.08969E-06 300 END
La-139 2940 0.000336966 300 END
Ce-141 2940 0.000162193 300 END
Pr-141 2940 0.000148579 300 END
Pr-143 2940 8.92975E-05 300 END
Nd-143 2940 0.000252001 300 END
Nd-145 2940 0.000210669 300 END
Nd-147 2940 2.40172E-05 300 END
Pm-147 2940 0.000210669 300 END
Pm-149 2940 4.92965E-07 300 END
Sm-149 2940 7.57766E-06 300 END
Sm-150 2940 5.50594E-05 300 END
Sm-151 2940 1.12116E-05 300 END
Sm-152 2940 3.06306E-05 300 END
Eu-153 2940 9.06487E-06 300 END
Eu-154 2940 2.10202E-07 300 END
Eu-155 2940 1.33669E-06 300 END
Gd-155 2940 6.71641E-09 300 END
Gd-157 2940 2.14072E-08 300 END

' 2971   ρ= 6.4401 MWD= 3.844809649
h-zrh2 2971 0.10313676 300 END
u-235 2971 0.092202767 300 END
u-238 2971 0.410372963 300 END
zr-90 2971 3.00127689 300 END
zr-91 2971 0.654576563 300 END
zr-92 2971 1.000805386 300 END
zr-94 2971 1.014170663 300 END
zr-96 2971 0.163582587 300 END
U-236 2971 0.001549843 300 END
Pu-239 2971 0.000297109 300 END
Pu-240 2971 1.63037E-05 300 END
Pu-241 2971 2.59948E-08 300 END
Np-237 2971 2.12344E-06 300 END
Kr-83 2971 1.57176E-05 300 END
I-129 2971 2.62574E-05 300 END
I-131 2971 1.91326E-05 300 END
Xe-131 2971 0.000130324 300 END
Xe-133 2971 2.62262E-05 300 END
Xe-135 2971 3.08835E-11 300 END
Mo-95 2971 2.50636E-05 300 END
Mo-97 2971 0.000227997 300 END
Tc-99 2971 0.000232722 300 END
Ru-101 2971 0.000200945 300 END
Rh-103 2971 5.02291E-05 300 END
Rh-105 2971 6.8785E-08 300 END
Pd-105 2971 3.53261E-05 300 END

Cd-113 2971 7.59938E-08 300 END
Cs-133 2971 0.000327178 300 END
Cs-134 2971 1.11814E-06 300 END
La-139 2971 0.000341165 300 END
Ce-141 2971 0.000163334 300 END
Pr-141 2971 0.000151277 300 END
Pr-143 2971 8.9617E-05 300 END
Nd-143 2971 0.000255142 300 END
Nd-145 2971 0.000213295 300 END
Nd-147 2971 2.40827E-05 300 END
Pm-147 2971 0.000213295 300 END
Pm-149 2971 4.93344E-07 300 END
Sm-149 2971 7.58089E-06 300 END
Sm-150 2971 5.57742E-05 300 END
Sm-151 2971 1.12585E-05 300 END
Sm-152 2971 3.10306E-05 300 END
Eu-153 2971 9.19116E-06 300 END
Eu-154 2971 2.15983E-07 300 END
Eu-155 2971 1.34722E-06 300 END
Gd-155 2971 6.7717E-09 300 END
Gd-157 2971 2.14105E-08 300 END

' 2969 ρ= 6.363 MWD= 4.048467845
h-zrh2 2969 0.101912044 300 END
u-235 2969 0.090428682 300 END
u-238 2969 0.405476138 300 END
zr-90 2969 2.965634888 300 END
zr-91 2969 0.646805519 300 END
zr-92 2969 0.98893921 300 END
zr-94 2969 1.002141839 300 END
zr-96 2969 0.161655011 300 END
U-236 2969 0.001631937 300 END
Pu-239 2969 0.000311066 300 END
Pu-240 2969 1.80339E-05 300 END
Pu-241 2969 2.73192E-08 300 END
Np-237 2969 2.35338E-06 300 END
Kr-83 2969 1.65501E-05 300 END
I-129 2969 2.76482E-05 300 END
I-131 2969 1.92862E-05 300 END
Xe-131 2969 0.000137227 300 END
Xe-133 2969 2.6311E-05 300 END
Xe-135 2969 3.08331E-11 300 END
Mo-95 2969 2.80219E-05 300 END
Mo-97 2969 0.000240074 300 END
Tc-99 2969 0.00024505 300 END
Ru-101 2969 0.000211589 300 END
Rh-103 2969 5.43347E-05 300 END
Rh-105 2969 6.88217E-08 300 END
Pd-105 2969 3.71973E-05 300 END
Cd-113 2969 7.58013E-08 300 END
Cs-133 2969 0.000344508 300 END
Cs-134 2969 1.2453E-06 300 END
La-139 2969 0.000359237 300 END
Ce-141 2969 0.00016808 300 END
Pr-141 2969 0.000163039 300 END
Pr-143 2969 9.09127E-05 300 END
Nd-143 2969 0.000268656 300 END
Nd-145 2969 0.000224593 300 END
Nd-147 2969 2.4346E-05 300 END
Pm-147 2969 0.000224593 300 END
Pm-149 2969 4.94936E-07 300 END
Sm-149 2969 7.59308E-06 300 END
Sm-150 2969 5.88579E-05 300 END
Sm-151 2969 1.14484E-05 300 END
Sm-152 2969 3.27569E-05 300 END

Eu-153 2969 9.7383E-06 300 END
Eu-154 2969 2.41835E-07 300 END
Eu-155 2969 1.39167E-06 300 END
Gd-155 2969 7.00554E-09 300 END
Gd-157 2969 2.14236E-08 300 END

' 6926   ρ= 6.2774 MWD= 5.456822254
h-zrh2 6926 0.100605558 300 END
u-235 6926 0.083712375 300 END
u-238 6926 0.401575781 300 END
zr-90 6926 2.927597866 300 END
zr-91 6926 0.638530079 300 END
zr-92 6926 0.976369038 300 END
zr-94 6926 0.989377409 300 END
zr-96 6926 0.159669996 300 END
U-236 6926 0.002199645 300 END
Pu-239 6926 0.000401828 300 END
Pu-240 6926 3.22934E-05 300 END
Pu-241 6926 3.63533E-08 300 END
Np-237 6926 4.29355E-06 300 END
Kr-83 6926 2.23075E-05 300 END
I-129 6926 3.72663E-05 300 END
I-131 6926 1.99663E-05 300 END
Xe-131 6926 0.000184964 300 END
Xe-133 6926 2.65519E-05 300 END
Xe-135 6926 3.04565E-11 300 END
Mo-95 6926 5.32875E-05 300 END
Mo-97 6926 0.00032359 300 END
Tc-99 6926 0.000330296 300 END
Ru-101 6926 0.000285195 300 END
Rh-103 6926 8.4982E-05 300 END
Rh-105 6926 6.89251E-08 300 END
Pd-105 6926 5.01373E-05 300 END
Cd-113 6926 7.37424E-08 300 END
Cs-133 6926 0.000464354 300 END
Cs-134 6926 2.34498E-06 300 END
La-139 6926 0.000484206 300 END
Ce-141 6926 0.000194557 300 END
Pr-141 6926 0.000250352 300 END
Pr-143 6926 9.71426E-05 300 END
Nd-143 6926 0.000362115 300 END
Nd-145 6926 0.000302723 300 END
Nd-147 6926 2.55502E-05 300 END
Pm-147 6926 0.000302723 300 END
Pm-149 6926 5.04814E-07 300 END
Sm-149 6926 7.62476E-06 300 END
Sm-150 6926 8.05391E-05 300 END
Sm-151 6926 1.23426E-05 300 END
Sm-152 6926 4.49216E-05 300 END
Eu-153 6926 1.36879E-05 300 END
Eu-154 6926 4.65052E-07 300 END
Eu-155 6926 1.66946E-06 300 END
Gd-155 6926 8.47532E-09 300 END
Gd-157 6926 2.14877E-08 300 END

' 3513   ρ= 6.4742 MWD= 5.039215539
h-zrh2 3513 0.103735264 300 END
u-235 3513 0.087444229 300 END
u-238 3513 0.414559295 300 END
zr-90 3513 3.018678846 300 END
zr-91 3513 0.658387847 300 END
zr-92 3513 1.006699337 300 END
zr-94 3513 1.02012234 300 END
zr-96 3513 0.16460198 300 END
U-236 3513 0.002031308 300 END

Pu-239 3513 0.000375957 300 END
Pu-240 3513 2.76492E-05 300 END
Pu-241 3513 3.36969E-08 300 END
Np-237 3513 3.65303E-06 300 END
Kr-83 3513 2.06003E-05 300 END
I-129 3513 3.44143E-05 300 END
I-131 3513 1.98202E-05 300 END
Xe-131 3513 0.000170809 300 END
Xe-133 3513 2.65293E-05 300 END
Xe-135 3513 3.05723E-11 300 END
Mo-95 3513 4.49169E-05 300 END
Mo-97 3513 0.000298825 300 END
Tc-99 3513 0.000305019 300 END
Ru-101 3513 0.00026337 300 END
Rh-103 3513 7.55243E-05 300 END
Rh-105 3513 6.89174E-08 300 END
Pd-105 3513 4.63003E-05 300 END
Cd-113 3513 7.44468E-08 300 END
Cs-133 3513 0.000428817 300 END
Cs-134 3513 1.97718E-06 300 END
La-139 3513 0.00044715 300 END
Ce-141 3513 0.000187741 300 END
Pr-141 3513 0.000223464 300 END
Pr-143 3513 9.57077E-05 300 END
Nd-143 3513 0.000334402 300 END
Nd-145 3513 0.000279556 300 END
Nd-147 3513 2.52844E-05 300 END
Pm-147 3513 0.000279556 300 END
Pm-149 3513 5.02039E-07 300 END
Sm-149 3513 7.62275E-06 300 END
Sm-150 3513 7.40452E-05 300 END
Sm-151 3513 1.21419E-05 300 END
Sm-152 3513 4.12731E-05 300 END
Eu-153 3513 1.24865E-05 300 END
Eu-154 3513 3.90629E-07 300 END
Eu-155 3513 1.59165E-06 300 END
Gd-155 3513 8.06241E-09 300 END
Gd-157 3513 2.14724E-08 300 END

' 10811 ρ= 6.2394 MWD= 1.715486301
h-zrh2 10811 0.09983916 300 END
u-235 10811 0.093204471 300 END
u-238 10811 0.39882358 300 END
zr-90 10811 2.905337313 300 END
zr-91 10811 0.633636879 300 END
zr-92 10811 0.968662938 300 END
zr-94 10811 0.981630763 300 END
zr-96 10811 0.158232312 300 END
U-236 10811 0.000691513 300 END
Pu-239 10811 0.000138776 300 END
Pu-240 10811 3.34337E-06 300 END
Pu-241 10811 1.18572E-08 300 END
Np-237 10811 4.38522E-07 300 END
Kr-83 10811 7.01291E-06 300 END
I-129 10811 1.17156E-05 300 END
I-131 10811 1.55404E-05 300 END
Xe-131 10811 5.81481E-05 300 END
Xe-133 10811 2.3294E-05 300 END
Xe-135 10811 3.12751E-11 300 END
Mo-95 10811 4.34479E-06 300 END
Mo-97 10811 0.000101728 300 END
Tc-99 10811 0.000103837 300 END
Ru-101 10811 8.96582E-05 300 END
Rh-103 10811 1.42314E-05 300 END
Rh-105 10811 6.77209E-08 300 END

Pd-105 10811 1.57619E-05 300 END
Cd-113 10811 7.26496E-08 300 END
Cs-133 10811 0.000145981 300 END
Cs-134 10811 2.17237E-07 300 END
La-139 10811 0.000152222 300 END
Ce-141 10811 9.40556E-05 300 END
Pr-141 10811 4.60296E-05 300 END
Pr-143 10811 6.42414E-05 300 END
Nd-143 10811 0.00011384 300 END
Nd-145 10811 9.51683E-05 300 END
Nd-147 10811 1.83972E-05 300 END
Pm-147 10811 9.51683E-05 300 END
Pm-149 10811 4.68663E-07 300 END
Sm-149 10811 7.11662E-06 300 END
Sm-150 10811 2.43122E-05 300 END
Sm-151 10811 7.6275E-06 300 END
Sm-152 10811 1.34796E-05 300 END
Eu-153 10811 3.83383E-06 300 END
Eu-154 10811 3.68732E-08 300 END
Eu-155 10811 7.69753E-07 300 END
Gd-155 10811 3.78541E-09 300 END
Gd-157 10811 2.10919E-08 300 END

' 2960   ρ= 6.4412 MWD= 4.070961275
h-zrh2 2960 0.103162818 300 END
u-235 2960 0.091612604 300 END
u-238 2960 0.410454743 300 END
zr-90 2960 3.002032542 300 END
zr-91 2960 0.654744009 300 END
zr-92 2960 1.001074673 300 END
zr-94 2960 1.01443966 300 END
zr-96 2960 0.163637389 300 END
U-236 2960 0.001641004 300 END
Pu-239 2960 0.000312594 300 END
Pu-240 2960 1.82302E-05 300 END
Pu-241 2960 2.74652E-08 300 END
Np-237 2960 2.37954E-06 300 END
Kr-83 2960 1.66421E-05 300 END
I-129 2960 2.78018E-05 300 END
I-131 2960 1.9302E-05 300 END
Xe-131 2960 0.000137989 300 END
Xe-133 2960 2.63193E-05 300 END
Xe-135 2960 3.08274E-11 300 END
Mo-95 2960 2.83594E-05 300 END
Mo-97 2960 0.000241408 300 END
Tc-99 2960 0.000246411 300 END
Ru-101 2960 0.000212765 300 END
Rh-103 2960 5.47938E-05 300 END
Rh-105 2960 6.88253E-08 300 END
Pd-105 2960 3.7404E-05 300 END
Cd-113 2960 7.57778E-08 300 END
Cs-133 2960 0.000346423 300 END
Cs-134 2960 1.25981E-06 300 END
La-139 2960 0.000361233 300 END
Ce-141 2960 0.000168589 300 END
Pr-141 2960 0.000164353 300 END
Pr-143 2960 9.10483E-05 300 END
Nd-143 2960 0.000270149 300 END
Nd-145 2960 0.000225841 300 END
Nd-147 2960 2.43733E-05 300 END
Pm-147 2960 0.000225841 300 END
Pm-149 2960 4.95108E-07 300 END
Sm-149 2960 7.59428E-06 300 END
Sm-150 2960 5.91993E-05 300 END
Sm-151 2960 1.14683E-05 300 END

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 Sm-152 2960 3.2948E-05  300 END
 Eu-153 2960 9.7991E-06  300 END
 Eu-154 2960 2.44787E-07  300 END
 Eu-155 2960 1.3965E-06  300 END
 Gd-155 2960 7.03098E-09  300 END
 Gd-157 2960 2.1425E-08  300 END

' 2947   ρ= 6.4058 MWD= 3.879101662
 h-zrh2 2947 0.102589547  300 END
 u-235 2947 0.09156457  300 END
 u-238 2947 0.408190543  300 END
 zr-90 2947 2.985352405  300 END
 zr-91 2947 0.651103869  300 END
 zr-92 2947 0.995499338  300 END
 zr-94 2947 1.008792868  300 END
 zr-96 2947 0.162717937  300 END
 U-236 2947 0.001563666  300 END
 Pu-239 2947 0.000299474  300 END
 Pu-240 2947 1.65891E-05  300 END
 Pu-241 2947 2.62181E-08  300 END
 Np-237 2947 2.16128E-06  300 END
 Kr-83 2947 1.58578E-05  300 END
 I-129 2947 2.64915E-05  300 END
 I-131 2947 1.91598E-05  300 END
 Xe-131 2947 0.000131486  300 END
 Xe-133 2947 2.62417E-05  300 END
 Xe-135 2947 3.08751E-11  300 END
 Mo-95 2947 2.55495E-05  300 END
 Mo-97 2947 0.000230031  300 END
 Tc-99 2947 0.000234798  300 END
 Ru-101 2947 0.000202737  300 END
 Rh-103 2947 5.09138E-05  300 END
 Rh-105 2947 6.87916E-08  300 END
 Pd-105 2947 3.56412E-05  300 END
 Cd-113 2947 7.59642E-08  300 END
 Cs-133 2947 0.000330096  300 END
 Cs-134 2947 1.13902E-06  300 END
 La-139 2947 0.000344208  300 END
 Ce-141 2947 0.000164152  300 END
 Pr-141 2947 0.000153241  300 END
 Pr-143 2947 8.9844E-05  300 END
 Nd-143 2947 0.000257417  300 END
 Nd-145 2947 0.000215197  300 END
 Nd-147 2947 2.41291E-05  300 END
 Pm-147 2947 0.000215197  300 END
 Pm-149 2947 4.93616E-07  300 END
 Sm-149 2947 7.58313E-06  300 END
 Sm-150 2947 5.62925E-05  300 END
 Sm-151 2947 1.12918E-05  300 END
 Sm-152 2947 3.13207E-05  300 END
 Eu-153 2947 9.28286E-06  300 END
 Eu-154 2947 2.20225E-07  300 END
 Eu-155 2947 1.35479E-06  300 END
 Gd-155 2947 6.81154E-09  300 END
 Gd-157 2947 2.14128E-08  300 END

' 2911   ρ= 6.3008 MWD= 4.15438145
 h-zrh2 2911 0.100921848  300 END
 u-235 2911 0.089154357  300 END
 u-238 2911 0.401522631  300 END
 zr-90 2911 2.936818614  300 END
 zr-91 2911 0.640522067  300 END
 zr-92 2911 0.979341015  300 END
 zr-94 2911 0.992413077  300 END
 zr-96 2911 0.160093031  300 END
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U-236 2911 0.001674631 300 END
Pu-239 2911 0.000318241 300 END
Pu-240 2911 1.89671E-05 300 END
Pu-241 2911 2.80062E-08 300 END
Np-237 2911 2.47789E-06 300 END
Kr-83 2911 1.69831E-05 300 END
I-129 2911 2.83715E-05 300 END
I-131 2911 1.93591E-05 300 END
Xe-131 2911 0.000140817 300 END
Xe-133 2911 2.63487E-05 300 END
Xe-135 2911 3.08063E-11 300 END
Mo-95 2911 2.96295E-05 300 END
Mo-97 2911 0.000246355 300 END
Tc-99 2911 0.000251461 300 END
Ru-101 2911 0.000217125 300 END
Rh-103 2911 5.65061E-05 300 END
Rh-105 2911 6.88381E-08 300 END
Pd-105 2911 3.81705E-05 300 END
Cd-113 2911 7.56867E-08 300 END
Cs-133 2911 0.000353521 300 END
Cs-134 2911 1.31448E-06 300 END
La-139 2911 0.000368635 300 END
Ce-141 2911 0.000170446 300 END
Pr-141 2911 0.00016925 300 END
Pr-143 2911 9.15388E-05 300 END
Nd-143 2911 0.000275685 300 END
Nd-145 2911 0.000230468 300 END
Nd-147 2911 2.44719E-05 300 END
Pm-147 2911 0.000230468 300 END
Pm-149 2911 4.95742E-07 300 END
Sm-149 2911 7.59844E-06 300 END
Sm-150 2911 6.04668E-05 300 END
Sm-151 2911 1.154E-05 300 END
Sm-152 2911 3.36579E-05 300 END
Eu-153 2911 1.00252E-05 300 END
Eu-154 2911 2.55909E-07 300 END
Eu-155 2911 1.41428E-06 300 END
Gd-155 2911 7.12465E-09 300 END
Gd-157 2911 2.14299E-08 300 END

' 5922   ρ= 6.2454 MWD= 5.366400348
h-zrh2 5922 0.100088539 300 END
u-235 5922 0.083958711 300 END
u-238 5922 0.399055387 300 END
zr-90 5922 2.912553684 300 END
zr-91 5922 0.635247485 300 END
zr-92 5922 0.971346658 300 END
zr-94 5922 0.984289396 300 END
zr-96 5922 0.15884571 300 END
U-236 5922 0.002163196 300 END
Pu-239 5922 0.0003963 300 END
Pu-240 5922 3.12583E-05 300 END
Pu-241 5922 3.57797E-08 300 END
Np-237 5922 4.15009E-06 300 END
Kr-83 5922 2.19378E-05 300 END
I-129 5922 3.66488E-05 300 END
I-131 5922 1.99378E-05 300 END
Xe-131 5922 0.0001819 300 END
Xe-133 5922 2.65496E-05 300 END
Xe-135 5922 3.04818E-11 300 END
Mo-95 5922 5.14122E-05 300 END
Mo-97 5922 0.000318228 300 END
Tc-99 5922 0.000324823 300 END
Ru-101 5922 0.00028047 300 END
Rh-103 5922 8.29106E-05 300 END

Rh-105 5922 6.89248E-08 300 END
Pd-105 5922 4.93065E-05 300 END
Cd-113 5922 7.38994E-08 300 END
Cs-133 5922 0.000456659 300 END
Cs-134 5922 2.26223E-06 300 END
La-139 5922 0.000476182 300 END
Ce-141 5922 0.000193147 300 END
Pr-141 5922 0.000244465 300 END
Pr-143 5922 9.6856E-05 300 END
Nd-143 5922 0.000356114 300 END
Nd-145 5922 0.000297706 300 END
Nd-147 5922 2.54979E-05 300 END
Pm-147 5922 0.000297706 300 END
Pm-149 5922 5.04221E-07 300 END
Sm-149 5922 7.62472E-06 300 END
Sm-150 5922 7.91284E-05 300 END
Sm-151 5922 1.2303E-05 300 END
Sm-152 5922 4.41286E-05 300 END
Eu-153 5922 1.34256E-05 300 END
Eu-154 5922 4.48339E-07 300 END
Eu-155 5922 1.65289E-06 300 END
Gd-155 5922 8.38729E-09 300 END
Gd-157 5922 2.14846E-08 300 END

' 10814   ρ= 6.2678 MWD= 1.616115275
h-zrh2 10814 0.100289005 300 END
u-235 10814 0.093916196 300 END
u-238 10814 0.400629748 300 END
zr-90 10814 2.918428814 300 END
zr-91 10814 0.636491793 300 END
zr-92 10814 0.973019936 300 END
zr-94 10814 0.986047624 300 END
zr-96 10814 0.158938852 300 END
U-236 10814 0.000651456 300 END
Pu-239 10814 0.000130867 300 END
Pu-240 10814 2.97154E-06 300 END
Pu-241 10814 1.11838E-08 300 END
Np-237 10814 3.90896E-07 300 END
Kr-83 10814 6.60668E-06 300 END
I-129 10814 1.10369E-05 300 END
I-131 10814 1.52032E-05 300 END
Xe-131 10814 5.47798E-05 300 END
Xe-133 10814 2.29642E-05 300 END
Xe-135 10814 3.12819E-11 300 END
Mo-95 10814 3.81558E-06 300 END
Mo-97 10814 9.58356E-05 300 END
Tc-99 10814 9.78218E-05 300 END
Ru-101 10814 8.44646E-05 300 END
Rh-103 10814 1.29411E-05 300 END
Rh-105 10814 6.76159E-08 300 END
Pd-105 10814 1.48489E-05 300 END
Cd-113 10814 7.19443E-08 300 END
Cs-133 10814 0.000137525 300 END
Cs-134 10814 1.92935E-07 300 END
La-139 10814 0.000143404 300 END
Ce-141 10814 8.97293E-05 300 END
Pr-141 10814 4.21088E-05 300 END
Pr-143 10814 6.21947E-05 300 END
Nd-143 10814 0.000107245 300 END
Nd-145 10814 8.96556E-05 300 END
Nd-147 10814 1.79006E-05 300 END
Pm-147 10814 8.96556E-05 300 END
Pm-149 10814 4.66631E-07 300 END
Sm-149 10814 7.06058E-06 300 END
Sm-150 10814 2.28787E-05 300 END

Sm-151 10814 7.34864E-06 300 END
Sm-152 10814 1.26827E-05 300 END
Eu-153 10814 3.60001E-06 300 END
Eu-154 10814 3.23554E-08 300 END
Eu-155 10814 7.35505E-07 300 END
Gd-155 10814 3.61188E-09 300 END
Gd-157 10814 2.10572E-08 300 END

' 10704 ρ= 6.2561 MWD= 1.310408611
h-zrh2 10704 0.106229206 300 END
u-235 10704 0.094489616 300 END
u-238 10704 0.399914384 300 END
zr-90 10704 2.909451755 300 END
zr-91 10704 0.634533229 300 END
zr-92 10704 0.97000506 300 END
zr-94 10704 0.982996642 300 END
zr-96 10704 0.158431827 300 END
U-236 10704 0.000528226 300 END
Pu-239 10704 0.000106293 300 END
Pu-240 10704 1.96134E-06 300 END
Pu-241 10704 9.1034E-09 300 END
Np-237 10704 2.61305E-07 300 END
Kr-83 10704 5.35695E-06 300 END
I-129 10704 8.94917E-06 300 END
I-131 10704 1.39697E-05 300 END
Xe-131 10704 4.44176E-05 300 END
Xe-133 10704 2.16983E-05 300 END
Xe-135 10704 3.12891E-11 300 END
Mo-95 10704 2.41702E-06 300 END
Mo-97 10704 7.77072E-05 300 END
Tc-99 10704 7.93177E-05 300 END
Ru-101 10704 6.84872E-05 300 END
Rh-103 10704 9.25401E-06 300 END
Rh-105 10704 6.72281E-08 300 END
Pd-105 10704 1.204E-05 300 END
Cd-113 10704 6.90141E-08 300 END
Cs-133 10704 0.000111511 300 END
Cs-134 10704 1.27402E-07 300 END
La-139 10704 0.000116278 300 END
Ce-141 10704 7.56568E-05 300 END
Pr-141 10704 3.07725E-05 300 END
Pr-143 10704 5.50741E-05 300 END
Nd-143 10704 8.69587E-05 300 END
Nd-145 10704 7.26962E-05 300 END
Nd-147 10704 1.61308E-05 300 END
Pm-147 10704 7.26962E-05 300 END
Pm-149 10704 4.58994E-07 300 END
Sm-149 10704 6.83839E-06 300 END
Sm-150 10704 1.84881E-05 300 END
Sm-151 10704 6.39758E-06 300 END
Sm-152 10704 1.02435E-05 300 END
Eu-153 10704 2.88974E-06 300 END
Eu-154 10704 2.04398E-08 300 END
Eu-155 10704 6.24095E-07 300 END
Gd-155 10704 3.05052E-09 300 END
Gd-157 10704 2.09182E-08 300 END

' 2908 ρ= 6.5572 MWD= 3.940897452
h-zrh2 2908 0.105012922 300 END
u-235 2908 0.093808796 300 END
u-238 2908 0.417834856 300 END
zr-90 2908 3.055872655 300 END
zr-91 2908 0.666484835 300 END
zr-92 2908 1.019013117 300 END
zr-94 2908 1.032620929 300 END

zr-96 2908 0.166559883 300 END
U-236 2908 0.001588576 300 END
Pu-239 2908 0.00030372 300 END
Pu-240 2908 1.71095E-05 300 END
Pu-241 2908 2.66202E-08 300 END
Np-237 2908 2.23037E-06 300 END
Kr-83 2908 1.61104E-05 300 END
I-129 2908 2.69136E-05 300 END
I-131 2908 1.92074E-05 300 END
Xe-131 2908 0.000133581 300 END
Xe-133 2908 2.62683E-05 300 END
Xe-135 2908 3.08599E-11 300 END
Mo-95 2908 2.64376E-05 300 END
Mo-97 2908 0.000233695 300 END
Tc-99 2908 0.000238539 300 END
Ru-101 2908 0.000205967 300 END
Rh-103 2908 5.21545E-05 300 END
Rh-105 2908 6.88031E-08 300 END
Pd-105 2908 3.6209E-05 300 END
Cd-113 2908 7.59079E-08 300 END
Cs-133 2908 0.000335355 300 END
Cs-134 2908 1.17718E-06 300 END
La-139 2908 0.000349692 300 END
Ce-141 2908 0.000165607 300 END
Pr-141 2908 0.000156796 300 END
Pr-143 2908 9.02439E-05 300 END
Nd-143 2908 0.000261518 300 END
Nd-145 2908 0.000218625 300 END
Nd-147 2908 2.42105E-05 300 END
Pm-147 2908 0.000218625 300 END
Pm-149 2908 4.94102E-07 300 END
Sm-149 2908 7.58697E-06 300 END
Sm-150 2908 5.72275E-05 300 END
Sm-151 2908 1.13504E-05 300 END
Sm-152 2908 3.1844E-05 300 END
Eu-153 2908 9.44855E-06 300 END
Eu-154 2908 2.27982E-07 300 END
Eu-155 2908 1.36835E-06 300 END
Gd-155 2908 6.88284E-09 300 END
Gd-157 2908 2.14168E-08 300 END

' 3700   ρ= 6.1493 MWD= 4.531871077
h-zrh2 3700 0.098517736 300 END
u-235 3700 0.083638051 300 END
u-238 3700 0.39382811 300 END
zr-90 3700 2.866853636 300 END
zr-91 3700 0.625267838 300 END
zr-92 3700 0.956046336 300 END
zr-94 3700 0.9687993 300 END
zr-96 3700 0.156307876 300 END
U-236 3700 0.001826797 300 END
Pu-239 3700 0.000343349 300 END
Pu-240 3700 2.24778E-05 300 END
Pu-241 3700 3.04445E-08 300 END
Np-237 3700 2.94951E-06 300 END
Kr-83 3700 1.85263E-05 300 END
I-129 3700 3.09495E-05 300 END
I-131 3700 1.95853E-05 300 END
Xe-131 3700 0.000153612 300 END
Xe-133 3700 2.64521E-05 300 END
Xe-135 3700 3.07086E-11 300 END
Mo-95 3700 3.57451E-05 300 END
Mo-97 3700 0.00026874 300 END
Tc-99 3700 0.00027431 300 END
Ru-101 3700 0.000236854 300 END

Rh-103 3700 6.4436E-05 300 END
Rh-105 3700 6.88838E-08 300 END
Pd-105 3700 4.16388E-05 300 END
Cd-113 3700 7.52113E-08 300 END
Cs-133 3700 0.000385644 300 END
Cs-134 3700 1.57839E-06 300 END
La-139 3700 0.000402131 300 END
Ce-141 3700 0.00017834 300 END
Pr-141 3700 0.00019189 300 END
Pr-143 3700 9.35319E-05 300 END
Nd-143 3700 0.000300735 300 END
Nd-145 3700 0.00025141 300 END
Nd-147 3700 2.48665E-05 300 END
Pm-147 3700 0.00025141 300 END
Pm-149 3700 4.98513E-07 300 END
Sm-149 3700 7.61281E-06 300 END
Sm-150 3700 6.62296E-05 300 END
Sm-151 3700 1.183E-05 300 END
Sm-152 3700 3.68875E-05 300 END
Eu-153 3700 1.10613E-05 300 END
Eu-154 3700 3.09613E-07 300 END
Eu-155 3700 1.4923E-06 300 END
Gd-155 3700 7.53647E-09 300 END
Gd-157 3700 2.14501E-08 300 END

' 6931   ρ= 6.2883 MWD= 1.321648567
h-zrh2 6931 0.100605558 300 END
u-235 6931 0.094977829 300 END
u-238 6931 0.401966373 300 END
zr-90 6931 2.927643098 300 END
zr-91 6931 0.638500725 300 END
zr-92 6931 0.976070245 300 END
zr-94 6931 0.989143011 300 END
zr-96 6931 0.159422605 300 END
U-236 6931 0.000532757 300 END
Pu-239 6931 0.000107203 300 END
Pu-240 6931 1.99489E-06 300 END
Pu-241 6931 9.18012E-09 300 END
Np-237 6931 2.65618E-07 300 END
Kr-83 6931 5.4029E-06 300 END
I-129 6931 9.02593E-06 300 END
I-131 6931 1.40212E-05 300 END
Xe-131 6931 4.47986E-05 300 END
Xe-133 6931 2.17529E-05 300 END
Xe-135 6931 3.12893E-11 300 END
Mo-95 6931 2.4624E-06 300 END
Mo-97 6931 7.83738E-05 300 END
Tc-99 6931 7.99981E-05 300 END
Ru-101 6931 6.90746E-05 300 END
Rh-103 6931 9.38163E-06 300 END
Rh-105 6931 6.72444E-08 300 END
Pd-105 6931 1.21433E-05 300 END
Cd-113 6931 6.91466E-08 300 END
Cs-133 6931 0.000112467 300 END
Cs-134 6931 1.29567E-07 300 END
La-139 6931 0.000117275 300 END
Ce-141 6931 7.61953E-05 300 END
Pr-141 6931 3.11688E-05 300 END
Pr-143 6931 5.53603E-05 300 END
Nd-143 6931 8.77046E-05 300 END
Nd-145 6931 7.33198E-05 300 END
Nd-147 6931 1.62032E-05 300 END
Pm-147 6931 7.33198E-05 300 END
Pm-149 6931 4.59323E-07 300 END
Sm-149 6931 6.84821E-06 300 END

Sm-150 6931 1.8649E-05 300 END
Sm-151 6931 6.43523E-06 300 END
Sm-152 6931 1.03328E-05 300 END
Eu-153 6931 2.91561E-06 300 END
Eu-154 6931 2.08258E-08 300 END
Eu-155 6931 6.28365E-07 300 END
Gd-155 6931 3.07194E-09 300 END
Gd-157 6931 2.09244E-08 300 END

' 5920   ρ= 6.247 MWD= 4.757600382
h-zrh2 5920 0.100088539 300 END
u-235 5920 0.085617265 300 END
u-238 5920 0.39911784 300 END
zr-90 5920 2.912561646 300 END
zr-91 5920 0.635239796 300 END
zr-92 5920 0.971301422 300 END
zr-94 5920 0.984254887 300 END
zr-96 5920 0.158809288 300 END
U-236 5920 0.001917789 300 END
Pu-239 5920 0.000358017 300 END
Pu-240 5920 2.47147E-05 300 END
Pu-241 5920 3.1895E-08 300 END
Np-237 5920 3.25254E-06 300 END
Kr-83 5920 1.94491E-05 300 END
I-129 5920 3.24911E-05 300 END
I-131 5920 1.96985E-05 300 END
Xe-131 5920 0.000161264 300 END
Xe-133 5920 2.64941E-05 300 END
Xe-135 5920 3.06486E-11 300 END
Mo-95 5920 3.96908E-05 300 END
Mo-97 5920 0.000282126 300 END
Tc-99 5920 0.000287973 300 END
Ru-101 5920 0.000248651 300 END
Rh-103 5920 6.93116E-05 300 END
Rh-105 5920 6.89023E-08 300 END
Pd-105 5920 4.37128E-05 300 END
Cd-113 5920 7.48861E-08 300 END
Cs-133 5920 0.000404853 300 END
Cs-134 5920 1.74946E-06 300 END
La-139 5920 0.000422161 300 END
Ce-141 5920 0.000182685 300 END
Pr-141 5920 0.000205782 300 END
Pr-143 5920 9.45648E-05 300 END
Nd-143 5920 0.000315714 300 END
Nd-145 5920 0.000263933 300 END
Nd-147 5920 2.50668E-05 300 END
Pm-147 5920 0.000263933 300 END
Pm-149 5920 5.00106E-07 300 END
Sm-149 5920 7.61839E-06 300 END
Sm-150 5920 6.9697E-05 300 END
Sm-151 5920 1.19788E-05 300 END
Sm-152 5920 3.88324E-05 300 END
Eu-153 5920 1.16908E-05 300 END
Eu-154 5920 3.44397E-07 300 END
Eu-155 5920 1.53722E-06 300 END
Gd-155 5920 7.77407E-09 300 END
Gd-157 5920 2.14606E-08 300 END

' 10701   ρ= 6.2215 MWD= 1.939598006
h-zrh2 10701 0.105671295 300 END
u-235 10701 0.092516098 300 END
u-238 10701 0.397525595 300 END
zr-90 10701 2.894165945 300 END
zr-91 10701 0.631201262 300 END
zr-92 10701 0.96495522 300 END

zr-94 10701 0.977870047 300 END
zr-96 10701 0.157637804 300 END
U-236 10701 0.000781852 300 END
Pu-239 10701 0.000156459 300 END
Pu-240 10701 4.25962E-06 300 END
Pu-241 10701 1.33714E-08 300 END
Np-237 10701 5.55873E-07 300 END
Kr-83 10701 7.92908E-06 300 END
I-129 10701 1.32461E-05 300 END
I-131 10701 1.62101E-05 300 END
Xe-131 10701 6.57446E-05 300 END
Xe-133 10701 2.39271E-05 300 END
Xe-135 10701 3.12535E-11 300 END
Mo-95 10701 5.67553E-06 300 END
Mo-97 10701 0.000115018 300 END
Tc-99 10701 0.000117402 300 END
Ru-101 10701 0.000101371 300 END
Rh-103 10701 1.72951E-05 300 END
Rh-105 10701 6.79283E-08 300 END
Pd-105 10701 1.7821E-05 300 END
Cd-113 10701 7.39121E-08 300 END
Cs-133 10701 0.000165052 300 END
Cs-134 10701 2.77536E-07 300 END
La-139 10701 0.000172108 300 END
Ce-141 10701 0.000103391 300 END
Pr-141 10701 5.52639E-05 300 END
Pr-143 10701 6.84466E-05 300 END
Nd-143 10701 0.000128712 300 END
Nd-145 10701 0.000107601 300 END
Nd-147 10701 1.94003E-05 300 END
Pm-147 10701 0.000107601 300 END
Pm-149 10701 4.72685E-07 300 END
Sm-149 10701 7.22209E-06 300 END
Sm-150 10701 2.75566E-05 300 END
Sm-151 10701 8.208E-06 300 END
Sm-152 10701 1.52841E-05 300 END
Eu-153 10701 4.36647E-06 300 END
Eu-154 10701 4.82517E-08 300 END
Eu-155 10701 8.43825E-07 300 END
Gd-155 10701 4.16223E-09 300 END
Gd-157 10701 2.11576E-08 300 END

' 2957   ρ= 6.5366 MWD= 3.707152877
h-zrh2 2957 0.10467417 300 END
u-235 2957 0.094108344 300 END
u-238 2957 0.416508461 300 END
zr-90 2957 3.046017573 300 END
zr-91 2957 0.664332854 300 END
zr-92 2957 1.01570986 300 END
zr-94 2957 1.029277365 300 END
zr-96 2957 0.16600937 300 END
U-236 2957 0.001494353 300 END
Pu-239 2957 0.000287555 300 END
Pu-240 2957 1.51822E-05 300 END
Pu-241 2957 2.50969E-08 300 END
Np-237 2957 1.97503E-06 300 END
Kr-83 2957 1.51548E-05 300 END
I-129 2957 2.53173E-05 300 END
I-131 2957 1.9018E-05 300 END
Xe-131 2957 0.000125658 300 END
Xe-133 2957 2.61587E-05 300 END
Xe-135 2957 3.09169E-11 300 END
Mo-95 2957 2.31627E-05 300 END
Mo-97 2957 0.000219834 300 END
Tc-99 2957 0.00022439 300 END

Ru-101 2957 0.000193751 300 END
Rh-103 2957 4.75083E-05 300 END
Rh-105 2957 6.87561E-08 300 END
Pd-105 2957 3.40613E-05 300 END
Cd-113 2957 7.61003E-08 300 END
Cs-133 2957 0.000315464 300 END
Cs-134 2957 1.03651E-06 300 END
La-139 2957 0.000328951 300 END
Ce-141 2957 0.000159973 300 END
Pr-141 2957 0.000143468 300 END
Pr-143 2957 8.86674E-05 300 END
Nd-143 2957 0.000246007 300 END
Nd-145 2957 0.000205658 300 END
Nd-147 2957 2.38876E-05 300 END
Pm-147 2957 0.000205658 300 END
Pm-149 2957 4.92233E-07 300 END
Sm-149 2957 7.57106E-06 300 END
Sm-150 2957 5.36972E-05 300 END
Sm-151 2957 1.11191E-05 300 END
Sm-152 2957 2.98685E-05 300 END
Eu-153 2957 8.82477E-06 300 END
Eu-154 2957 1.99405E-07 300 END
Eu-155 2957 1.3164E-06 300 END
Gd-155 2957 6.60985E-09 300 END
Gd-157 2957 2.14008E-08 300 END

' 2938   ρ= 6.5266 MWD= 3.812003217
h-zrh2 2938 0.104517824 300 END
u-235 2938 0.093667051 300 END
u-238 2938 0.415875768 300 END
zr-90 2938 3.041466636 300 END
zr-91 2938 0.663341458 300 END
zr-92 2938 1.014200757 300 END
zr-94 2938 1.02774624 300 END
zr-96 2938 0.165768014 300 END
U-236 2938 0.001536618 300 END
Pu-239 2938 0.000294841 300 END
Pu-240 2938 1.60329E-05 300 END
Pu-241 2938 2.5781E-08 300 END
Np-237 2938 2.08756E-06 300 END
Kr-83 2938 1.55835E-05 300 END
I-129 2938 2.60333E-05 300 END
I-131 2938 1.91062E-05 300 END
Xe-131 2938 0.000129212 300 END
Xe-133 2938 2.62109E-05 300 END
Xe-135 2938 3.08915E-11 300 END
Mo-95 2938 2.46034E-05 300 END
Mo-97 2938 0.000226052 300 END
Tc-99 2938 0.000230737 300 END
Ru-101 2938 0.000199231 300 END
Rh-103 2938 4.95767E-05 300 END
Rh-105 2938 6.87784E-08 300 END
Pd-105 2938 3.50247E-05 300 END
Cd-113 2938 7.60211E-08 300 END
Cs-133 2938 0.000324386 300 END
Cs-134 2938 1.09838E-06 300 END
La-139 2938 0.000338254 300 END
Ce-141 2938 0.000162545 300 END
Pr-141 2938 0.000149406 300 END
Pr-143 2938 8.93963E-05 300 END
Nd-143 2938 0.000252965 300 END
Nd-145 2938 0.000211475 300 END
Nd-147 2938 2.40375E-05 300 END
Pm-147 2938 0.000211475 300 END
Pm-149 2938 4.93082E-07 300 END

Sm-149 2938 7.57867E-06 300 END
Sm-150 2938 5.52787E-05 300 END
Sm-151 2938 1.12261E-05 300 END
Sm-152 2938 3.07533E-05 300 END
Eu-153 2938 9.10359E-06 300 END
Eu-154 2938 2.11966E-07 300 END
Eu-155 2938 1.33993E-06 300 END
Gd-155 2938 6.73342E-09 300 END
Gd-157 2938 2.14083E-08 300 END

' 2927   ρ= 6.5453 MWD= 4.119590909
h-zrh2 2927 0.104830517 300 END
u-235 2927 0.09314039 300 END
u-238 2927 0.417091054 300 END
zr-90 2927 3.050562524 300 END
zr-91 2927 0.665328844 300 END
zr-92 2927 1.017256654 300 END
zr-94 2927 1.030837812 300 END
zr-96 2927 0.166281673 300 END
U-236 2927 0.001660607 300 END
Pu-239 2927 0.00031589 300 END
Pu-240 2927 1.8658E-05 300 END
Pu-241 2927 2.77807E-08 300 END
Np-237 2927 2.43662E-06 300 END
Kr-83 2927 1.68409E-05 300 END
I-129 2927 2.81339E-05 300 END
I-131 2927 1.93356E-05 300 END
Xe-131 2927 0.000139638 300 END
Xe-133 2927 2.63367E-05 300 END
Xe-135 2927 3.08152E-11 300 END
Mo-95 2927 2.90962E-05 300 END
Mo-97 2927 0.000244292 300 END
Tc-99 2927 0.000249355 300 END
Ru-101 2927 0.000215306 300 END
Rh-103 2927 5.57902E-05 300 END
Rh-105 2927 6.88329E-08 300 END
Pd-105 2927 3.78508E-05 300 END
Cd-113 2927 7.57254E-08 300 END
Cs-133 2927 0.000350561 300 END
Cs-134 2927 1.29152E-06 300 END
La-139 2927 0.000365548 300 END
Ce-141 2927 0.000169676 300 END
Pr-141 2927 0.000167203 300 END
Pr-143 2927 9.13366E-05 300 END
Nd-143 2927 0.000273376 300 END
Nd-145 2927 0.000228538 300 END
Nd-147 2927 2.44313E-05 300 END
Pm-147 2927 0.000228538 300 END
Pm-149 2927 4.95479E-07 300 END
Sm-149 2927 7.59675E-06 300 END
Sm-150 2927 5.99379E-05 300 END
Sm-151 2927 1.15104E-05 300 END
Sm-152 2927 3.33617E-05 300 END
Eu-153 2927 9.9308E-06 300 END
Eu-154 2927 2.51238E-07 300 END
Eu-155 2927 1.40689E-06 300 END
Gd-155 2927 7.08571E-09 300 END
Gd-157 2927 2.14279E-08 300 END

' 10702   ρ= 6.2217 MWD= 1.987370787
h-zrh2 10702 0.105676078 300 END
u-235 10702 0.092126534 300 END
u-238 10702 0.397780831 300 END
zr-90 10702 2.894296506 300 END
zr-91 10702 0.631229937 300 END

zr-92 10702 0.965002258 300 END
zr-94 10702 0.977917011 300 END
zr-96 10702 0.157647792 300 END
U-236 10702 0.000801109 300 END
Pu-239 10702 0.0001602 300 END
Pu-240 10702 4.46878E-06 300 END
Pu-241 10702 1.36933E-08 300 END
Np-237 10702 5.82674E-07 300 END
Kr-83 10702 8.12437E-06 300 END
I-129 10702 1.35724E-05 300 END
I-131 10702 1.63386E-05 300 END
Xe-131 10702 6.73639E-05 300 END
Xe-133 10702 2.4045E-05 300 END
Xe-135 10702 3.1248E-11 300 END
Mo-95 10702 5.98405E-06 300 END
Mo-97 10702 0.000117851 300 END
Tc-99 10702 0.000120294 300 END
Ru-101 10702 0.000103868 300 END
Rh-103 10702 1.79745E-05 300 END
Rh-105 10702 6.79679E-08 300 END
Pd-105 10702 1.826E-05 300 END
Cd-113 10702 7.41314E-08 300 END
Cs-133 10702 0.000169117 300 END
Cs-134 10702 2.91383E-07 300 END
La-139 10702 0.000176347 300 END
Ce-141 10702 0.000105308 300 END
Pr-141 10702 5.72994E-05 300 END
Pr-143 10702 6.92758E-05 300 END
Nd-143 10702 0.000131882 300 END
Nd-145 10702 0.000110251 300 END
Nd-147 10702 1.95954E-05 300 END
Pm-147 10702 0.000110251 300 END
Pm-149 10702 4.7346E-07 300 END
Sm-149 10702 7.24144E-06 300 END
Sm-150 10702 2.82502E-05 300 END
Sm-151 10702 8.32365E-06 300 END
Sm-152 10702 1.567E-05 300 END
Eu-153 10702 4.48096E-06 300 END
Eu-154 10702 5.08931E-08 300 END
Eu-155 10702 8.59082E-07 300 END
Gd-155 10702 4.2401E-09 300 END
Gd-157 10702 2.11697E-08 300 END

' 2970   ρ= 6.5463 MWD= 3.759734839
h-zrh2 2970 0.104830517 300 END
u-235 2970 0.094120745 300 END
u-238 2970 0.417126007 300 END
zr-90 2970 3.050566714 300 END
zr-91 2970 0.66532558 300 END
zr-92 2970 1.017230409 300 END
zr-94 2970 1.030817414 300 END
zr-96 2970 0.166260145 300 END
U-236 2970 0.001515549 300 END
Pu-239 2970 0.000291216 300 END
Pu-240 2970 1.5606E-05 300 END
Pu-241 2970 2.54401E-08 300 END
Np-237 2970 2.03106E-06 300 END
Kr-83 2970 1.53698E-05 300 END
I-129 2970 2.56764E-05 300 END
I-131 2970 1.90629E-05 300 END
Xe-131 2970 0.00012744 300 END
Xe-133 2970 2.61855E-05 300 END
Xe-135 2970 3.09042E-11 300 END
Mo-95 2970 2.38795E-05 300 END
Mo-97 2970 0.000222952 300 END

Tc-99 2970 0.000227573 300 END
Ru-101 2970 0.000196499 300 END
Rh-103 2970 4.85423E-05 300 END
Rh-105 2970 6.87675E-08 300 END
Pd-105 2970 3.45444E-05 300 END
Cd-113 2970 7.60621E-08 300 END
Cs-133 2970 0.000319938 300 END
Cs-134 2970 1.06728E-06 300 END
La-139 2970 0.000333616 300 END
Ce-141 2970 0.000161272 300 END
Pr-141 2970 0.000146437 300 END
Pr-143 2970 8.90375E-05 300 END
Nd-143 2970 0.000249496 300 END
Nd-145 2970 0.000208575 300 END
Nd-147 2970 2.39638E-05 300 END
Pm-147 2970 0.000208575 300 END
Pm-149 2970 4.92661E-07 300 END
Sm-149 2970 7.57498E-06 300 END
Sm-150 2970 5.44899E-05 300 END
Sm-151 2970 1.11734E-05 300 END
Sm-152 2970 3.0312E-05 300 END
Eu-153 2970 8.96439E-06 300 END
Eu-154 2970 2.05652E-07 300 END
Eu-155 2970 1.32825E-06 300 END
Gd-155 2970 6.67205E-09 300 END
Gd-157 2970 2.14046E-08 300 END

' 2976 ρ= 6.5757 MWD= 3.742082668
h-zrh2 2976 0.105299558 300 END
u-235 2976 0.094635786 300 END
u-238 2976 0.418995506 300 END
zr-90 2976 3.064216135 300 END
zr-91 2976 0.668302285 300 END
zr-92 2976 1.021779308 300 END
zr-94 2976 1.035427618 300 END
zr-96 2976 0.167001975 300 END
U-236 2976 0.001508434 300 END
Pu-239 2976 0.000289988 300 END
Pu-240 2976 1.54631E-05 300 END
Pu-241 2976 2.53249E-08 300 END
Np-237 2976 2.01216E-06 300 END
Kr-83 2976 1.52976E-05 300 END
I-129 2976 2.55558E-05 300 END
I-131 2976 1.9048E-05 300 END
Xe-131 2976 0.000126842 300 END
Xe-133 2976 2.61766E-05 300 END
Xe-135 2976 3.09085E-11 300 END
Mo-95 2976 2.36376E-05 300 END
Mo-97 2976 0.000221906 300 END
Tc-99 2976 0.000226505 300 END
Ru-101 2976 0.000195576 300 END
Rh-103 2976 4.81944E-05 300 END
Rh-105 2976 6.87638E-08 300 END
Pd-105 2976 3.43823E-05 300 END
Cd-113 2976 7.60753E-08 300 END
Cs-133 2976 0.000318436 300 END
Cs-134 2976 1.0569E-06 300 END
La-139 2976 0.00033205 300 END
Ce-141 2976 0.000160838 300 END
Pr-141 2976 0.000145439 300 END
Pr-143 2976 8.89143E-05 300 END
Nd-143 2976 0.000248325 300 END
Nd-145 2976 0.000207596 300 END
Nd-147 2976 2.39385E-05 300 END
Pm-147 2976 0.000207596 300 END

Pm-149 2976 4.92518E-07 300 END
Sm-149 2976 7.57369E-06 300 END
Sm-150 2976 5.42237E-05 300 END
Sm-151 2976 1.11553E-05 300 END
Sm-152 2976 3.0163E-05 300 END
Eu-153 2976 8.91748E-06 300 END
Eu-154 2976 2.03543E-07 300 END
Eu-155 2976 1.32428E-06 300 END
Gd-155 2976 6.65122E-09 300 END
Gd-157 2976 2.14033E-08 300 END

' 2952   ρ= 6.9053 MWD= 3.566292449
h-zrh2 2952 0.110563233 300 END
u-235 2952 0.100354911 300 END
u-238 2952 0.439973217 300 END
zr-90 2952 3.217392693 300 END
zr-91 2952 0.701707773 300 END
zr-92 2952 1.072829703 300 END
zr-94 2952 1.08716562 300 END
zr-96 2952 0.1753283 300 END
U-236 2952 0.001437572 300 END
Pu-239 2952 0.000277679 300 END
Pu-240 2952 1.40746E-05 300 END
Pu-241 2952 2.41759E-08 300 END
Np-237 2952 1.82899E-06 300 END
Kr-83 2952 1.4579E-05 300 END
I-129 2952 2.43553E-05 300 END
I-131 2952 1.88907E-05 300 END
Xe-131 2952 0.000120883 300 END
Xe-133 2952 2.608E-05 300 END
Xe-135 2952 3.09503E-11 300 END
Mo-95 2952 2.12998E-05 300 END
Mo-97 2952 0.000211481 300 END
Tc-99 2952 0.000215864 300 END
Ru-101 2952 0.000186389 300 END
Rh-103 2952 4.47713E-05 300 END
Rh-105 2952 6.87229E-08 300 END
Pd-105 2952 3.27671E-05 300 END
Cd-113 2952 7.61865E-08 300 END
Cs-133 2952 0.000303477 300 END
Cs-134 2952 9.56515E-07 300 END
La-139 2952 0.000316451 300 END
Ce-141 2952 0.000156399 300 END
Pr-141 2952 0.000135599 300 END
Pr-143 2952 8.76287E-05 300 END
Nd-143 2952 0.000236659 300 END
Nd-145 2952 0.000197844 300 END
Nd-147 2952 2.36723E-05 300 END
Pm-147 2952 0.000197844 300 END
Pm-149 2952 4.91062E-07 300 END
Sm-149 2952 7.55952E-06 300 END
Sm-150 2952 5.15781E-05 300 END
Sm-151 2952 1.09665E-05 300 END
Sm-152 2952 2.86833E-05 300 END
Eu-153 2952 8.45272E-06 300 END
Eu-154 2952 1.83183E-07 300 END
Eu-155 2952 1.28417E-06 300 END
Gd-155 2952 6.44085E-09 300 END
Gd-157 2952 2.13902E-08 300 END

' 10815   ρ= 6.2831 MWD= 1.463143693
h-zrh2 10815 0.100527158 300 END
u-235 10815 0.094566412 300 END
u-238 10815 0.401594501 300 END
zr-90 10815 2.925360461 300 END

zr-91 10815 0.638003171 300 END
zr-92 10815 0.975319565 300 END
zr-94 10815 0.988380274 300 END
zr-96 10815 0.159306898 300 END
U-236 10815 0.000589793 300 END
Pu-239 10815 0.000118615 300 END
Pu-240 10815 2.44073E-06 300 END
Pu-241 10815 1.01444E-08 300 END
Np-237 10815 3.2286E-07 300 END
Kr-83 10815 5.98133E-06 300 END
I-129 10815 9.99225E-06 300 END
I-131 10815 1.46266E-05 300 END
Xe-131 10815 4.95947E-05 300 END
Xe-133 10815 2.2384E-05 300 END
Xe-135 10815 3.12884E-11 300 END
Mo-95 10815 3.07286E-06 300 END
Mo-97 10815 8.67644E-05 300 END
Tc-99 10815 8.85626E-05 300 END
Ru-101 10815 7.64697E-05 300 END
Rh-103 10815 1.10411E-05 300 END
Rh-105 10815 6.74354E-08 300 END
Pd-105 10815 1.34434E-05 300 END
Cd-113 10815 7.06403E-08 300 END
Cs-133 10815 0.000124508 300 END
Cs-134 10815 1.58412E-07 300 END
La-139 10815 0.000129831 300 END
Ce-141 10815 8.2835E-05 300 END
Pr-141 10815 3.62946E-05 300 END
Pr-143 10815 5.87976E-05 300 END
Nd-143 10815 9.70942E-05 300 END
Nd-145 10815 8.11694E-05 300 END
Nd-147 10815 1.70645E-05 300 END
Pm-147 10815 8.11694E-05 300 END
Pm-149 10815 4.63113E-07 300 END
Sm-149 10815 6.96015E-06 300 END
Sm-150 10815 2.0678E-05 300 END
Sm-151 10815 6.89119E-06 300 END
Sm-152 10815 1.14598E-05 300 END
Eu-153 10815 3.24289E-06 300 END
Eu-154 10815 2.60228E-08 300 END
Eu-155 10815 6.8095E-07 300 END
Gd-155 10815 3.33639E-09 300 END
Gd-157 10815 2.09947E-08 300 END

' 2904 ρ= 6.9514 MWD= 4.024014229
h-zrh2 2904 0.111318909 300 END
u-235 2904 0.099860248 300 END
u-238 2904 0.442938315 300 END
zr-90 2904 3.239377858 300 END
zr-91 2904 0.706507746 300 END
zr-92 2904 1.080193853 300 END
zr-94 2904 1.094620729 300 END
zr-96 2904 0.176552557 300 END
U-236 2904 0.00162208 300 END
Pu-239 2904 0.000309401 300 END
Pu-240 2904 1.78217E-05 300 END
Pu-241 2904 2.71604E-08 300 END
Np-237 2904 2.32511E-06 300 END
Kr-83 2904 1.64502E-05 300 END
I-129 2904 2.74812E-05 300 END
I-131 2904 1.92687E-05 300 END
Xe-131 2904 0.000136398 300 END
Xe-133 2904 2.63017E-05 300 END
Xe-135 2904 3.08392E-11 300 END
Mo-95 2904 2.76575E-05 300 END

Mo-97 2904 0.000238624 300 END
Tc-99 2904 0.00024357 300 END
Ru-101 2904 0.000210311 300 END
Rh-103 2904 5.38368E-05 300 END
Rh-105 2904 6.88176E-08 300 END
Pd-105 2904 3.69726E-05 300 END
Cd-113 2904 7.58265E-08 300 END
Cs-133 2904 0.000342428 300 END
Cs-134 2904 1.22962E-06 300 END
La-139 2904 0.000357067 300 END
Ce-141 2904 0.000167524 300 END
Pr-141 2904 0.000161614 300 END
Pr-143 2904 9.07637E-05 300 END
Nd-143 2904 0.000267034 300 END
Nd-145 2904 0.000223236 300 END
Nd-147 2904 2.43158E-05 300 END
Pm-147 2904 0.000223236 300 END
Pm-149 2904 4.94748E-07 300 END
Sm-149 2904 7.59176E-06 300 END
Sm-150 2904 5.8487E-05 300 END
Sm-151 2904 1.14266E-05 300 END
Sm-152 2904 3.25491E-05 300 END
Eu-153 2904 9.67228E-06 300 END
Eu-154 2904 2.38647E-07 300 END
Eu-155 2904 1.3864E-06 300 END
Gd-155 2904 6.9778E-09 300 END
Gd-157 2904 2.14221E-08 300 END

' 2968   ρ= 6.5126 MWD= 3.534404846
h-zrh2 2968 0.104283304 300 END
u-235 2968 0.094189837 300 END
u-238 2968 0.414968471 300 END
zr-90 2968 3.034645164 300 END
zr-91 2968 0.66185076 300 END
zr-92 2968 1.011905511 300 END
zr-94 2968 1.025424902 300 END
zr-96 2968 0.165379963 300 END
U-236 2968 0.001424719 300 END
Pu-239 2968 0.00027543 300 END
Pu-240 2968 1.38295E-05 300 END
Pu-241 2968 2.39671E-08 300 END
Np-237 2968 1.79674E-06 300 END
Kr-83 2968 1.44486E-05 300 END
I-129 2968 2.41375E-05 300 END
I-131 2968 1.88603E-05 300 END
Xe-131 2968 0.000119802 300 END
Xe-133 2968 2.60607E-05 300 END
Xe-135 2968 3.09577E-11 300 END
Mo-95 2968 2.08896E-05 300 END
Mo-97 2968 0.00020959 300 END
Tc-99 2968 0.000213934 300 END
Ru-101 2968 0.000184722 300 END
Rh-103 2968 4.41585E-05 300 END
Rh-105 2968 6.87149E-08 300 END
Pd-105 2968 3.24741E-05 300 END
Cd-113 2968 7.62026E-08 300 END
Cs-133 2968 0.000300764 300 END
Cs-134 2968 9.38899E-07 300 END
La-139 2968 0.000313622 300 END
Ce-141 2968 0.000155571 300 END
Pr-141 2968 0.000133835 300 END
Pr-143 2968 8.73837E-05 300 END
Nd-143 2968 0.000234543 300 END
Nd-145 2968 0.000196075 300 END
Nd-147 2968 2.36212E-05 300 END

Pm-147 2968 0.000196075 300 END
Pm-149 2968 4.90792E-07 300 END
Sm-149 2968 7.55668E-06 300 END
Sm-150 2968 5.10992E-05 300 END
Sm-151 2968 1.09306E-05 300 END
Sm-152 2968 2.84156E-05 300 END
Eu-153 2968 8.3689E-06 300 END
Eu-154 2968 1.79614E-07 300 END
Eu-155 2968 1.27677E-06 300 END
Gd-155 2968 6.4021E-09 300 END
Gd-157 2968 2.13876E-08 300 END

' 2903 ρ= 6.5164 MWD= 3.972576865
h-zrh2 2903 0.104361477 300 END
u-235 2903 0.09307395 300 END
u-238 2903 0.415237608 300 END
zr-90 2903 3.036915036 300 END
zr-91 2903 0.662350605 300 END
zr-92 2903 1.012695731 300 END
zr-94 2903 1.026218274 300 END
zr-96 2903 0.165529991 300 END
U-236 2903 0.001601346 300 END
Pu-239 2903 0.000305889 300 END
Pu-240 2903 1.73793E-05 300 END
Pu-241 2903 2.68262E-08 300 END
Np-237 2903 2.26624E-06 300 END
Kr-83 2903 1.62399E-05 300 END
I-129 2903 2.71299E-05 300 END
I-131 2903 1.92311E-05 300 END
Xe-131 2903 0.000134654 300 END
Xe-133 2903 2.62814E-05 300 END
Xe-135 2903 3.0852E-11 300 END
Mo-95 2903 2.68991E-05 300 END
Mo-97 2903 0.000235574 300 END
Tc-99 2903 0.000240456 300 END
Ru-101 2903 0.000207623 300 END
Rh-103 2903 5.27939E-05 300 END
Rh-105 2903 6.88088E-08 300 END
Pd-105 2903 3.65E-05 300 END
Cd-113 2903 7.58776E-08 300 END
Cs-133 2903 0.00033805 300 END
Cs-134 2903 1.19702E-06 300 END
La-139 2903 0.000352503 300 END
Ce-141 2903 0.000166343 300 END
Pr-141 2903 0.000158628 300 END
Pr-143 2903 9.04445E-05 300 END
Nd-143 2903 0.00026362 300 END
Nd-145 2903 0.000220383 300 END
Nd-147 2903 2.42512E-05 300 END
Pm-147 2903 0.000220383 300 END
Pm-149 2903 4.94349E-07 300 END
Sm-149 2903 7.58885E-06 300 END
Sm-150 2903 5.77073E-05 300 END
Sm-151 2903 1.13798E-05 300 END
Sm-152 2903 3.21126E-05 300 END
Eu-153 2903 9.5337E-06 300 END
Eu-154 2903 2.32015E-07 300 END
Eu-155 2903 1.37526E-06 300 END
Gd-155 2903 6.91916E-09 300 END
Gd-157 2903 2.14189E-08 300 END

' 2935 ρ= 6.5138 MWD= 3.723525238
h-zrh2 2935 0.104309361 300 END
u-235 2935 0.093700558 300 END
u-238 2935 0.415054154 300 END

zr-90 2935 3.035401327 300 END
zr-91 2935 0.66201766 300 END
zr-92 2935 1.012172019 300 END
zr-94 2935 1.0256918 300 END
zr-96 2935 0.165432548 300 END
U-236 2935 0.001500953 300 END
Pu-239 2935 0.000288696 300 END
Pu-240 2935 1.53135E-05 300 END
Pu-241 2935 2.52038E-08 300 END
Np-237 2935 1.99239E-06 300 END
Kr-83 2935 1.52218E-05 300 END
I-129 2935 2.54291E-05 300 END
I-131 2935 1.90321E-05 300 END
Xe-131 2935 0.000126213 300 END
Xe-133 2935 2.61672E-05 300 END
Xe-135 2935 3.09129E-11 300 END
Mo-95 2935 2.33847E-05 300 END
Mo-97 2935 0.000220805 300 END
Tc-99 2935 0.000225381 300 END
Ru-101 2935 0.000194606 300 END
Rh-103 2935 4.78295E-05 300 END
Rh-105 2935 6.87597E-08 300 END
Pd-105 2935 3.42117E-05 300 END
Cd-113 2935 7.60887E-08 300 END
Cs-133 2935 0.000316857 300 END
Cs-134 2935 1.04604E-06 300 END
La-139 2935 0.000330403 300 END
Ce-141 2935 0.000160379 300 END
Pr-141 2935 0.000144391 300 END
Pr-143 2935 8.87836E-05 300 END
Nd-143 2935 0.000247093 300 END
Nd-145 2935 0.000206566 300 END
Nd-147 2935 2.39116E-05 300 END
Pm-147 2935 0.000206566 300 END
Pm-149 2935 4.92367E-07 300 END
Sm-149 2935 7.5723E-06 300 END
Sm-150 2935 5.39439E-05 300 END
Sm-151 2935 1.11362E-05 300 END
Sm-152 2935 3.00065E-05 300 END
Eu-153 2935 8.8682E-06 300 END
Eu-154 2935 2.01339E-07 300 END
Eu-155 2935 1.3201E-06 300 END
Gd-155 2935 6.62927E-09 300 END
Gd-157 2935 2.1402E-08 300 END

' 2930   ρ= 6.4728 MWD= 3.832580649
h-zrh2 2930 0.103657916 300 END
u-235 2930 0.092754916 300 END
u-238 2930 0.412449479 300 END
zr-90 2930 3.01644283 300 END
zr-91 2930 0.657884071 300 END
zr-92 2930 1.005860254 300 END
zr-94 2930 1.019293531 300 END
zr-96 2930 0.164407286 300 END
U-236 2930 0.001544913 300 END
Pu-239 2930 0.000296264 300 END
Pu-240 2930 1.62025E-05 300 END
Pu-241 2930 2.59151E-08 300 END
Np-237 2930 2.11002E-06 300 END
Kr-83 2930 1.56676E-05 300 END
I-129 2930 2.61738E-05 300 END
I-131 2930 1.91228E-05 300 END
Xe-131 2930 0.000129909 300 END
Xe-133 2930 2.62206E-05 300 END
Xe-135 2930 3.08865E-11 300 END

Mo-95 2930 2.48915E-05 300 END
Mo-97 2930 0.000227272 300 END
Tc-99 2930 0.000231982 300 END
Ru-101 2930 0.000200306 300 END
Rh-103 2930 4.99856E-05 300 END
Rh-105 2930 6.87825E-08 300 END
Pd-105 2930 3.52138E-05 300 END
Cd-113 2930 7.60041E-08 300 END
Cs-133 2930 0.000326137 300 END
Cs-134 2930 1.11075E-06 300 END
La-139 2930 0.00034008 300 END
Ce-141 2930 0.000163041 300 END
Pr-141 2930 0.000150579 300 END
Pr-143 2930 8.95351E-05 300 END
Nd-143 2930 0.00025433 300 END
Nd-145 2930 0.000212616 300 END
Nd-147 2930 2.40659E-05 300 END
Pm-147 2930 0.000212616 300 END
Pm-149 2930 4.93246E-07 300 END
Sm-149 2930 7.58007E-06 300 END
Sm-150 2930 5.55895E-05 300 END
Sm-151 2930 1.12465E-05 300 END
Sm-152 2930 3.09272E-05 300 END
Eu-153 2930 9.1585E-06 300 END
Eu-154 2930 2.14481E-07 300 END
Eu-155 2930 1.3445E-06 300 END
Gd-155 2930 6.75745E-09 300 END
Gd-157 2930 2.14097E-08 300 END

' 2951 ρ= 6.4717 MWD= 3.603074039
h-zrh2 2951 0.103631859 300 END
u-235 2951 0.093354219 300 END
u-238 2951 0.412367757 300 END
zr-90 2951 3.015687147 300 END
zr-91 2951 0.657716779 300 END
zr-92 2951 1.00559079 300 END
zr-94 2951 1.019024343 300 END
zr-96 2951 0.164352284 300 END
U-236 2951 0.001452399 300 END
Pu-239 2951 0.000280268 300 END
Pu-240 2951 1.43599E-05 300 END
Pu-241 2951 2.44166E-08 300 END
Np-237 2951 1.86656E-06 300 END
Kr-83 2951 1.47294E-05 300 END
I-129 2951 2.46065E-05 300 END
I-131 2951 1.89249E-05 300 END
Xe-131 2951 0.00012213 300 END
Xe-133 2951 2.61015E-05 300 END
Xe-135 2951 3.09416E-11 300 END
Mo-95 2951 2.17783E-05 300 END
Mo-97 2951 0.000213662 300 END
Tc-99 2951 0.00021809 300 END
Ru-101 2951 0.000188311 300 END
Rh-103 2951 4.54813E-05 300 END
Rh-105 2951 6.8732E-08 300 END
Pd-105 2951 3.3105E-05 300 END
Cd-113 2951 7.61664E-08 300 END
Cs-133 2951 0.000306607 300 END
Cs-134 2951 9.77059E-07 300 END
La-139 2951 0.000319715 300 END
Ce-141 2951 0.000157346 300 END
Pr-141 2951 0.000137641 300 END
Pr-143 2951 8.79067E-05 300 END
Nd-143 2951 0.0002391 300 END
Nd-145 2951 0.000199884 300 END

Nd-147 2951 2.37301E-05 300 END
Pm-147 2951 0.000199884 300 END
Pm-149 2951 4.91372E-07 300 END
Sm-149 2951 7.56269E-06 300 END
Sm-150 2951 5.21308E-05 300 END
Sm-151 2951 1.10074E-05 300 END
Sm-152 2951 2.89924E-05 300 END
Eu-153 2951 8.54959E-06 300 END
Eu-154 2951 1.87347E-07 300 END
Eu-155 2951 1.29266E-06 300 END
Gd-155 2951 6.48532E-09 300 END
Gd-157 2951 2.1393E-08 300 END

' 10699   ρ= 6.2557 MWD= 1.435805825
h-zrh2 10699 0.106229206 300 END
u-235 10699 0.094147996 300 END
u-238 10699 0.399903768 300 END
zr-90 10699 2.909450707 300 END
zr-91 10699 0.634533241 300 END
zr-92 10699 0.970013811 300 END
zr-94 10699 0.98300375 300 END
zr-96 10699 0.158439329 300 END
U-236 10699 0.000578773 300 END
Pu-239 10699 0.000116416 300 END
Pu-240 10699 2.3512E-06 300 END
Pu-241 10699 9.9583E-09 300 END
Np-237 10699 3.11374E-07 300 END
Kr-83 10699 5.86957E-06 300 END
I-129 10699 9.80555E-06 300 END
I-131 10699 1.45154E-05 300 END
Xe-131 10699 4.86681E-05 300 END
Xe-133 10699 2.22697E-05 300 END
Xe-135 10699 3.1289E-11 300 END
Mo-95 10699 2.94922E-06 300 END
Mo-97 10699 8.51433E-05 300 END
Tc-99 10699 8.69079E-05 300 END
Ru-101 10699 7.5041E-05 300 END
Rh-103 10699 1.0713E-05 300 END
Rh-105 10699 6.74005E-08 300 END
Pd-105 10699 1.31922E-05 300 END
Cd-113 10699 7.03753E-08 300 END
Cs-133 10699 0.000122181 300 END
Cs-134 10699 1.52609E-07 300 END
La-139 10699 0.000127405 300 END
Ce-141 10699 8.15721E-05 300 END
Pr-141 10699 3.52849E-05 300 END
Pr-143 10699 5.81566E-05 300 END
Nd-143 10699 9.52801E-05 300 END
Nd-145 10699 7.96528E-05 300 END
Nd-147 10699 1.69051E-05 300 END
Pm-147 10699 7.96528E-05 300 END
Pm-149 10699 4.62426E-07 300 END
Sm-149 10699 6.94009E-06 300 END
Sm-150 10699 2.02855E-05 300 END
Sm-151 10699 6.80564E-06 300 END
Sm-152 10699 1.12417E-05 300 END
Eu-153 10699 3.17943E-06 300 END
Eu-154 10699 2.49696E-08 300 END
Eu-155 10699 6.70955E-07 300 END
Gd-155 10699 3.28604E-09 300 END
Gd-157 10699 2.09821E-08 300 END

' 2948   ρ= 6.6014 MWD= 3.873230734
h-zrh2 2948 0.105716482 300 END
u-235 2948 0.094693566 300 END

u-238 2948 0.42064312 300 END
zr-90 2948 3.07634727 300 END
zr-91 2948 0.670949509 300 END
zr-92 2948 1.025833458 300 END
zr-94 2948 1.039533901 300 END
zr-96 2948 0.167670165 300 END
U-236 2948 0.001561299 300 END
Pu-239 2948 0.000299069 300 END
Pu-240 2948 1.65401E-05 300 END
Pu-241 2948 2.61799E-08 300 END
Np-237 2948 2.15478E-06 300 END
Kr-83 2948 1.58338E-05 300 END
I-129 2948 2.64515E-05 300 END
I-131 2948 1.91552E-05 300 END
Xe-131 2948 0.000131287 300 END
Xe-133 2948 2.62391E-05 300 END
Xe-135 2948 3.08766E-11 300 END
Mo-95 2948 2.5466E-05 300 END
Mo-97 2948 0.000229683 300 END
Tc-99 2948 0.000234443 300 END
Ru-101 2948 0.000202431 300 END
Rh-103 2948 5.07964E-05 300 END
Rh-105 2948 6.87905E-08 300 END
Pd-105 2948 3.55872E-05 300 END
Cd-113 2948 7.59694E-08 300 END
Cs-133 2948 0.000329596 300 END
Cs-134 2948 1.13543E-06 300 END
La-139 2948 0.000343687 300 END
Ce-141 2948 0.000164013 300 END
Pr-141 2948 0.000152904 300 END
Pr-143 2948 8.98054E-05 300 END
Nd-143 2948 0.000257028 300 END
Nd-145 2948 0.000214871 300 END
Nd-147 2948 2.41212E-05 300 END
Pm-147 2948 0.000214871 300 END
Pm-149 2948 4.9357E-07 300 END
Sm-149 2948 7.58275E-06 300 END
Sm-150 2948 5.62038E-05 300 END
Sm-151 2948 1.12861E-05 300 END
Sm-152 2948 3.1271E-05 300 END
Eu-153 2948 9.26715E-06 300 END
Eu-154 2948 2.19495E-07 300 END
Eu-155 2948 1.3535E-06 300 END
Gd-155 2948 6.80473E-09 300 END
Gd-157 2948 2.14124E-08 300 END

' 2913   ρ= 6.5263 MWD= 3.924166208
h-zrh2 2913 0.104517824 300 END
u-235 2913 0.093361485 300 END
u-238 2913 0.415864913 300 END
zr-90 2913 3.04146534 300 END
zr-91 2913 0.663342449 300 END
zr-92 2913 1.014208927 300 END
zr-94 2913 1.027752598 300 END
zr-96 2913 0.165774724 300 END
U-236 2913 0.001581831 300 END
Pu-239 2913 0.000302572 300 END
Pu-240 2913 1.69679E-05 300 END
Pu-241 2913 2.65114E-08 300 END
Np-237 2913 2.21155E-06 300 END
Kr-83 2913 1.6042E-05 300 END
I-129 2913 2.67993E-05 300 END
I-131 2913 1.91946E-05 300 END
Xe-131 2913 0.000133014 300 END
Xe-133 2913 2.62613E-05 300 END

Xe-135 2913 3.0864E-11 300 END
Mo-95 2913 2.61956E-05 300 END
Mo-97 2913 0.000232703 300 END
Tc-99 2913 0.000237526 300 END
Ru-101 2913 0.000205093 300 END
Rh-103 2913 5.18177E-05 300 END
Rh-105 2913 6.88001E-08 300 END
Pd-105 2913 3.60552E-05 300 END
Cd-113 2913 7.59235E-08 300 END
Cs-133 2913 0.000333931 300 END
Cs-134 2913 1.16678E-06 300 END
La-139 2913 0.000348207 300 END
Ce-141 2913 0.000165215 300 END
Pr-141 2913 0.000155831 300 END
Pr-143 2913 9.01368E-05 300 END
Nd-143 2913 0.000260408 300 END
Nd-145 2913 0.000217697 300 END
Nd-147 2913 2.41887E-05 300 END
Pm-147 2913 0.000217697 300 END
Pm-149 2913 4.93971E-07 300 END
Sm-149 2913 7.58596E-06 300 END
Sm-150 2913 5.69743E-05 300 END
Sm-151 2913 1.13347E-05 300 END
Sm-152 2913 3.17023E-05 300 END
Eu-153 2913 9.40363E-06 300 END
Eu-154 2913 2.25867E-07 300 END
Eu-155 2913 1.36469E-06 300 END
Gd-155 2913 6.86359E-09 300 END
Gd-157 2913 2.14158E-08 300 END

' 2954 ρ= 6.5148 MWD= 3.958216822
h-zrh2 2954 0.104335419 300 END
u-235 2954 0.093087129 300 END
u-238 2954 0.415135238 300 END
zr-90 2954 3.036156914 300 END
zr-91 2954 0.662185093 300 END
zr-92 2954 1.012441895 300 END
zr-94 2954 1.025961282 300 END
zr-96 2954 0.165487861 300 END
U-236 2954 0.001595557 300 END
Pu-239 2954 0.000304907 300 END
Pu-240 2954 1.72568E-05 300 END
Pu-241 2954 2.67329E-08 300 END
Np-237 2954 2.24994E-06 300 END
Kr-83 2954 1.61812E-05 300 END
I-129 2954 2.70319E-05 300 END
I-131 2954 1.92204E-05 300 END
Xe-131 2954 0.000134168 300 END
Xe-133 2954 2.62755E-05 300 END
Xe-135 2954 3.08556E-11 300 END
Mo-95 2954 2.66894E-05 300 END
Mo-97 2954 0.000234722 300 END
Tc-99 2954 0.000239587 300 END
Ru-101 2954 0.000206872 300 END
Rh-103 2954 5.25038E-05 300 END
Rh-105 2954 6.88062E-08 300 END
Pd-105 2954 3.63681E-05 300 END
Cd-113 2954 7.58914E-08 300 END
Cs-133 2954 0.000336828 300 END
Cs-134 2954 1.188E-06 300 END
La-139 2954 0.000351228 300 END
Ce-141 2954 0.00016601 300 END
Pr-141 2954 0.000157797 300 END
Pr-143 2954 9.03539E-05 300 END
Nd-143 2954 0.000262667 300 END

Nd-145 2954 0.000219586 300 END
Nd-147 2954 2.42328E-05 300 END
Pm-147 2954 0.000219586 300 END
Pm-149 2954 4.94237E-07 300 END
Sm-149 2954 7.588E-06 300 END
Sm-150 2954 5.74898E-05 300 END
Sm-151 2954 1.13666E-05 300 END
Sm-152 2954 3.19908E-05 300 END
Eu-153 2954 9.49508E-06 300 END
Eu-154 2954 2.30182E-07 300 END
Eu-155 2954 1.37213E-06 300 END
Gd-155 2954 6.90272E-09 300 END
Gd-157 2954 2.1418E-08 300 END

' 10700   ρ= 6.2532 MWD= 2.385760945
h-zrh2 10700 0.106229206 300 END
u-235 10700 0.091560034 300 END
u-238 10700 0.399820863 300 END
zr-90 10700 2.909442113 300 END
zr-91 10700 0.634535165 300 END
zr-92 10700 0.970080733 300 END
zr-94 10700 0.983057598 300 END
zr-96 10700 0.158496161 300 END
U-236 10700 0.0009617 300 END
Pu-239 10700 0.000190987 300 END
Pu-240 10700 6.4013E-06 300 END
Pu-241 10700 1.63666E-08 300 END
Np-237 10700 8.30759E-07 300 END
Kr-83 10700 9.75299E-06 300 END
I-129 10700 1.62931E-05 300 END
I-131 10700 1.72526E-05 300 END
Xe-131 10700 8.08678E-05 300 END
Xe-133 10700 2.48482E-05 300 END
Xe-135 10700 3.1191E-11 300 END
Mo-95 10700 8.90299E-06 300 END
Mo-97 10700 0.000141476 300 END
Tc-99 10700 0.000144408 300 END
Ru-101 10700 0.000124689 300 END
Rh-103 10700 2.39762E-05 300 END
Rh-105 10700 6.82475E-08 300 END
Pd-105 10700 2.19204E-05 300 END
Cd-113 10700 7.54436E-08 300 END
Cs-133 10700 0.000203019 300 END
Cs-134 10700 4.20714E-07 300 END
La-139 10700 0.000211698 300 END
Ce-141 10700 0.000120352 300 END
Pr-141 10700 7.51267E-05 300 END
Pr-143 10700 7.54043E-05 300 END
Nd-143 10700 0.000158319 300 END
Nd-145 10700 0.000132352 300 END
Nd-147 10700 2.10092E-05 300 END
Pm-147 10700 0.000132352 300 END
Pm-149 10700 4.79102E-07 300 END
Sm-149 10700 7.37069E-06 300 END
Sm-150 10700 3.40625E-05 300 END
Sm-151 10700 9.18984E-06 300 END
Sm-152 10700 1.89064E-05 300 END
Eu-153 10700 5.44872E-06 300 END
Eu-154 10700 7.59387E-08 300 END
Eu-155 10700 9.798E-07 300 END
Gd-155 10700 4.85913E-09 300 END
Gd-157 10700 2.12523E-08 300 END

' 2918   ρ= 6.2934 MWD= 3.878492675
h-zrh2 2918 0.100791559 300 END

u-235 2918 0.089776253 300 END
u-238 2918 0.401030698 300 END
zr-90 2918 2.933030403 300 END
zr-91 2918 0.639692591 300 END
zr-92 2918 0.978056929 300 END
zr-94 2918 0.991116548 300 END
zr-96 2918 0.159870168 300 END
U-236 2918 0.00156342 300 END
Pu-239 2918 0.000299432 300 END
Pu-240 2918 1.65841E-05 300 END
Pu-241 2918 2.62141E-08 300 END
Np-237 2918 2.16061E-06 300 END
Kr-83 2918 1.58553E-05 300 END
I-129 2918 2.64874E-05 300 END
I-131 2918 1.91593E-05 300 END
Xe-131 2918 0.000131465 300 END
Xe-133 2918 2.62414E-05 300 END
Xe-135 2918 3.08753E-11 300 END
Mo-95 2918 2.55408E-05 300 END
Mo-97 2918 0.000229995 300 END
Tc-99 2918 0.000234761 300 END
Ru-101 2918 0.000202706 300 END
Rh-103 2918 5.09017E-05 300 END
Rh-105 2918 6.87915E-08 300 END
Pd-105 2918 3.56356E-05 300 END
Cd-113 2918 7.59647E-08 300 END
Cs-133 2918 0.000330044 300 END
Cs-134 2918 1.13865E-06 300 END
La-139 2918 0.000344154 300 END
Ce-141 2918 0.000164138 300 END
Pr-141 2918 0.000153206 300 END
Pr-143 2918 8.984E-05 300 END
Nd-143 2918 0.000257377 300 END
Nd-145 2918 0.000215163 300 END
Nd-147 2918 2.41282E-05 300 END
Pm-147 2918 0.000215163 300 END
Pm-149 2918 4.93611E-07 300 END
Sm-149 2918 7.58309E-06 300 END
Sm-150 2918 5.62833E-05 300 END
Sm-151 2918 1.12912E-05 300 END
Sm-152 2918 3.13155E-05 300 END
Eu-153 2918 9.28123E-06 300 END
Eu-154 2918 2.20149E-07 300 END
Eu-155 2918 1.35466E-06 300 END
Gd-155 2918 6.81083E-09 300 END
Gd-157 2918 2.14128E-08 300 END

' 10810   ρ= 6.2398 MWD= 1.532222743
h-zrh2 10810 0.09983916 300 END
u-235 10810 0.093703736 300 END
u-238 10810 0.398839319 300 END
zr-90 10810 2.905338904 300 END
zr-91 10810 0.633636696 300 END
zr-92 10810 0.968650092 300 END
zr-94 10810 0.981620375 300 END
zr-96 10810 0.158221348 300 END
U-236 10810 0.000617639 300 END
Pu-239 10810 0.000124159 300 END
Pu-240 10810 2.67418E-06 300 END
Pu-241 10810 1.06141E-08 300 END
Np-237 10810 3.52792E-07 300 END
Kr-83 10810 6.26373E-06 300 END
I-129 10810 1.0464E-05 300 END
I-131 10810 1.48962E-05 300 END
Xe-131 10810 5.19362E-05 300 END

Xe-133 10810 2.26578E-05 300 END
Xe-135 10810 3.12861E-11 300 END
Mo-95 10810 3.39753E-06 300 END
Mo-97 10810 9.08608E-05 300 END
Tc-99 10810 9.27439E-05 300 END
Ru-101 10810 8.00801E-05 300 END
Rh-103 10810 1.18858E-05 300 END
Rh-105 10810 6.752E-08 300 END
Pd-105 10810 1.40781E-05 300 END
Cd-113 10810 7.12649E-08 300 END
Cs-133 10810 0.000130386 300 END
Cs-134 10810 1.73571E-07 300 END
La-139 10810 0.00013596 300 END
Ce-141 10810 8.59841E-05 300 END
Pr-141 10810 3.88861E-05 300 END
Pr-143 10810 6.03704E-05 300 END
Nd-143 10810 0.000101678 300 END
Nd-145 10810 8.50016E-05 300 END
Nd-147 10810 1.74535E-05 300 END
Pm-147 10810 8.50016E-05 300 END
Pm-149 10810 4.64767E-07 300 END
Sm-149 10810 7.00784E-06 300 END
Sm-150 10810 2.16709E-05 300 END
Sm-151 10810 7.10215E-06 300 END
Sm-152 10810 1.20114E-05 300 END
Eu-153 10810 3.40374E-06 300 END
Eu-154 10810 2.87898E-08 300 END
Eu-155 10810 7.0587E-07 300 END
Gd-155 10810 3.46209E-09 300 END
Gd-157 10810 2.10244E-08 300 END

' 10703   ρ= 6.2561 MWD= 1.309437465
h-zrh2 10703 0.106229206 300 END
u-235 10703 0.094492262 300 END
u-238 10703 0.399914466 300 END
zr-90 10703 2.909451764 300 END
zr-91 10703 0.634533229 300 END
zr-92 10703 0.970004992 300 END
zr-94 10703 0.982996587 300 END
zr-96 10703 0.158431769 300 END
U-236 10703 0.000527834 300 END
Pu-239 10703 0.000106214 300 END
Pu-240 10703 1.95845E-06 300 END
Pu-241 10703 9.09677E-09 300 END
Np-237 10703 2.60934E-07 300 END
Kr-83 10703 5.35298E-06 300 END
I-129 10703 8.94254E-06 300 END
I-131 10703 1.39652E-05 300 END
Xe-131 10703 4.43847E-05 300 END
Xe-133 10703 2.16935E-05 300 END
Xe-135 10703 3.12891E-11 300 END
Mo-95 10703 2.41312E-06 300 END
Mo-97 10703 7.76496E-05 300 END
Tc-99 10703 7.92589E-05 300 END
Ru-101 10703 6.84364E-05 300 END
Rh-103 10703 9.24302E-06 300 END
Rh-105 10703 6.72267E-08 300 END
Pd-105 10703 1.20311E-05 300 END
Cd-113 10703 6.90026E-08 300 END
Cs-133 10703 0.000111428 300 END
Cs-134 10703 1.27216E-07 300 END
La-139 10703 0.000116192 300 END
Ce-141 10703 7.56102E-05 300 END
Pr-141 10703 3.07383E-05 300 END
Pr-143 10703 5.50493E-05 300 END

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  Nd-143 10703 8.68943E-05  300 END
  Nd-145 10703 7.26424E-05  300 END
  Nd-147 10703 1.61245E-05  300 END
  Pm-147 10703 7.26424E-05  300 END
  Pm-149 10703 4.58966E-07  300 END
  Sm-149 10703 6.83753E-06  300 END
  Sm-150 10703 1.84742E-05  300 END
  Sm-151 10703 6.39431E-06  300 END
  Sm-152 10703 1.02358E-05  300 END
  Eu-153 10703 2.8875E-06  300 END
  Eu-154 10703 2.04066E-08  300 END
  Eu-155 10703 6.23726E-07  300 END
  Gd-155 10703 3.04867E-09  300 END
  Gd-157 10703 2.09177E-08  300 END
end composition
'
read depletion
    15
  5920  6931  3700  2908  10704 10701 10816 3703  3504  3496
  5911  10817 10703 2957  2915  6886  5915  2932  6932  5845
  10814 10810 2938 2946  5912  2992  2906  2959  2910  6928
  5922  2927  6924  5846  2962  2984  2965  2975  6142  2947
  2918  10702  10812  5903  10147  2944  3384  2985  2964  2955
  5914  2911  2958  5917  2928  2931  10878  10809  2979  2929
  6889  2960  2970  5913  6929  2939  2983  3013  2899  2941
  2950  6930  10811  10700  2976  5918  10146  2980  2925  10148
  5904  3513  2954  2952  6925  2977  2974  2905  2943  5902
  6926  2913  10815  2902  5844  6923  5919  5921  6927  2969
  2948  2904  10813  2912  6143  5916  2940  2971  10699  2968
  2903  2935  2930  2951
end depletion
'
read burndata
  power=55.5278   burn=0.00011574074  down=0.00694444444  end
  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=55.5278   burn=0.00011574074  down=0.00694444444  end
'  power=36.5   burn=0.00011574074  down=0.00694444444  end
'
'  power=36.5   burn=30  down=1  end
'
```

```
end burndata
'
read keep
  origen kenovi
end keep
read opus
   TITLE = "Irradiation of U-235"
   matl=15 end
   typa=nucl libtype=fisact
   units=BECQ
   time=SECONDS
   symnuc=U Ba Mo end
   NRANK=500
end opus
read model
read parameter
 gen=100
 npg=40
 nsk=50
 htm=no
 flx=yes
 ngp=238
 cfx=yes
 plt=yes
 end parameter
READ START
    NST=1
    XSM=-30
    XSP=30
    YSM=-30
    YSP=30
    ZSM=-23.0
    ZSP=23.0
   PSP=YES
END START
read geometry
global UNIT 1
com="UNIT 1: reflector and core"
 rhexprism 10   25.161   32.309  -36.424   rotate  a1=0 a2=0 a3=60
 rhexprism 11   25.796   32.309  -36.424   rotate  a1=0 a2=0 a3=60
 cylinder 20   30.083   32.309    6.509
 cylinder 21   30.718   32.309    6.509
 cylinder 22   31.115   32.309    6.509
 cylinder 23   35.401   32.309    6.509
 cylinder 24   36.671   32.309    6.509
 cylinder 40    59.69   32.309  -36.424
 cylinder 41    59.69   90       32.309
 cylinder 60    59.69   90      -36.424
 xcylinder 50     7.62       90      -90   origin  x=0 y=35.255 z=-6.985
 ycylinder 51     7.62      -10      -90   origin  x=-33 y=10 z=-6.985   rotate  a1=0 a2=0 a3=-30
 ycylinder 52     7.62        0      -90   origin  x=0 y=0 z=-6.985
 ycylinder 53     7.62        0      -90   origin  x=0 y=0 z=-6.985   rotate  a1=0 a2=0 a3=60
 array 1 10  place 8 8 1 0 0 0
 HOLE  10                  origin         x=-15.237 y=9.09005 z=0
 media 2 1 41
 media 5 1 11 -10
 media 4 1 40 -24 -11 -50 -51 -52 -53
 media 6 1 50 40 -11
 media 6 1 51 40 -11
 media 6 1 52 40 -11
 media 6 1 53 40 -11
 media 6 1 20 -11
 media 5 1 21 -20
 media 5 1 22 -21
 media 5 1 23 -22
```

```
 media 5 1 24 -23
 boundary 60
'
UNIT 10
 cylinder  1  2.400000    90.6017   -33.1723
 cylinder 20  2.38125     89.3895    10.3251
 cylinder 21  2.30759     89.2895   -33.1623
 cylinder 22  2.23393     89.2895   -27.13768
 cylinder 23  2.1708999   39.10232  -21.22268
 cylinder 24  2.1208999   39.10232  -21.85768
 cylinder 25  2.0472400   13.70232  -21.22268
 cylinder 26  2.0066000   36.56232   13.70232
 cylinder 27  1.0375900   86.6017   -18.68268
 cylinder 28  0.9525000   89.2895   -18.38268
 cylinder 29  0.8635000   89.2895   -18.25418
 cylinder 30  0.7940000   89.2895   -18.25418
 cylinder 31  0.6700000   89.2895   -18.13018
 cylinder 32  0.5900000  -9.00000   -16.67275
 cylinder 33  0.4500000  -10.1600   -15.87275
'
 cylinder 34  2.1900898   86.6017    39.20232
 cylinder 35  1.8923000   86.4017    39.20232
 cylinder 36  1.1112500   86.4017    39.20232
'
 cylinder 37  2.23393     -21.85768   -21.95768
 cylinder 38  2.23393     -21.95768   -22.05768
 cylinder 39  2.23393     -22.05768   -27.13768
 cylinder 40  2.03393     -22.25768   -27.13768
'
 media 2   1  1   -20 -21
 media 5   1  20  -21
 media 5   1  21  -22
 media 6   1  22  -23 -34 -36 -27 -28 -24 -37 -38 -39
 media 11  1  23  -24
 media 5   1  24  -25 -26 -27
 media 13  1  25  -26 -27
 media 13  1  26  -27
 media 5   1  27  -28
 media 5   1  28  -29
 media 6   1  29  -30
 media 5   1  30  -31 -32
 media 6   1  31  -32
 media 14  1  32  -33
 media 15  1  33
'
 media 5   1  34 -35 -27 -28
 media 16  1  35 -36
 media 5   1  36 -27
'
 media 11   1  37
 media 12   1  38
 media 5    1  39 -40
 media 6    1  40
'
 boundary 1
'
UNIT 2
com="UNIT 2: grid plate boundary UNITs"
com=" aluminmum grid plate bounding water - no penetration"
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 hexprism 50    2.177  -33.249  -36.424
 media 5 1 40
 media 5 1 50
 media 2 1 30 -40 -50
```

```
 boundary 30
'
UNIT 3
com="UNIT 3: water channel"
com=" like UNIT 2 with grid plates penetration"
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
 hexprism 50    2.177  -33.249  -36.424
 media 5 1 40 -41
 media 5 1 50 -41
 media 2 1 30 -40 -41 -50
 media 2 1 41
 boundary 30
'
UNIT 4
com="UNIT 4: graphite rod channel"
com=" like UNIT 3 with a graphite rod in the penetration"
com="  upper/lower end fitting (60/63)"
com="  cladding (61 less 62)"
com="  graphite (62)"
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
 hexprism 50    2.177  -33.249  -36.424
' graphite rod assembly
 cone     60    0.635   32.309   1.8796   30.569
 cylinder 61    1.877   30.569  -28.169
 cylinder 62    1.800   30.569  -28.169
 cone     63    1.877  -28.169    0.635  -34.441
' UNIT cell structure
 media 5 1 40 -41
 media 5 1 50 -41
 media 2 1 30 -40 -41 -50
 media 2 1 41 -60 -61 -63
' graphite rod
 media 5 1 60
 media 5 1 61 -62
 media 4 1 62
 media 5 1 63
 boundary 30
'
UNIT 8
com="UNIT 8: transient rod"
com=" like UNIT 3 with control rod in the penetration"
com=" guide tube   (42 r=1.892 to 43 r=1.727)  MAT 5"
com=" cladding     (60 r=1.588 to 61 r=1.516)  MAT 5"
com=" gap          (61 r=1.516 to 62 r=1.511)  MAT 6"
com=" poison       (62 r=1.516) MAT 7"
com=" air follower (63) MAT 6"
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
' guide tube
 cylinder 42    1.892   32.309  -36.424
 cylinder 43    1.727   32.309  -36.424
'
 hexprism 50    2.177  -33.249  -36.424
'
 CYLINDER 60    1.588   23.680  -73.144   origin  x=0 y=0 z=19.05
 CYLINDER 61    1.516   19.050  -19.050   origin  x=0 y=0 z=19.05
 CYLINDER 62    1.511   19.050  -19.050   origin  x=0 y=0 z=19.05
 CYLINDER 63    1.516  -22.979  -70       origin  x=0 y=0 z=19.05
' NOTE: grid plate to guide tube is last in this section
 media 5 1 40 -41
```

```
 media 5 1 50 -41
 media 2 1 30 -40 -41 -50
 media 2 1 41 -42
' Guide tube and water in guide tube outside cladding
 media 5 1 42 -43
 media 2 1 43 -60
' Trnsient rod
 media 5 1 60 -61 -63
 media 6 1 61 -62
 media 7 1 62
 media 6 1 63
 boundary 30
'
UNIT 2985
com="UNIT 2985 channel -- B01"
' UNIT cell structure 2985
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2985 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3384
com="UNIT 3384 channel -- B02"
' UNIT cell structure 3384
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
```

```
 media 3384 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10878
com="UNIT 10878 channel -- B03"
' UNIT cell structure 10878
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10878 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3013
com="UNIT 3013 channel -- B04"
' UNIT cell structure 3013
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
```

```
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3013 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2899
com="UNIT 2899 channel -- B05"
' UNIT cell structure 2899
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2899 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10809
com="UNIT 10809 channel -- B06"
' UNIT cell structure 10809
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
```

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 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10809 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2965
com="UNIT 2965 channel -- C02"
' UNIT cell structure 2965
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2965 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2984
com="UNIT 2984 channel -- C03"
' UNIT cell structure 2984
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
```

```
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2984 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2944
com="UNIT 2944 channel -- C04"
' UNIT cell structure 2944
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2944 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2931
com="UNIT 2931 channel -- C05"
' UNIT cell structure 2931
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
```

```
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2931 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2983
com="UNIT 2983 channel -- C06"
' UNIT cell structure 2983
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2983 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2980
com="UNIT 2980 channel -- C08"
' UNIT cell structure 2980
```

```
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2980 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2925
com="UNIT 2925 channel -- C09"
' UNIT cell structure 2925
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2925 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30
```

```
UNIT 2941
com="UNIT 2941 channel -- C10"
' UNIT cell structure 2941
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2941 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2979
com="UNIT 2979 channel -- C11"
' UNIT cell structure 2979
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2979 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
```

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 media 3 1 68
 boundary 30

UNIT 2964
com="UNIT 2964 channel -- C12"
' UNIT cell structure 2964
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2964 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2910
com="UNIT 2910 channel -- D01"
' UNIT cell structure 2910
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2910 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
```

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 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2959
com="UNIT 2959 channel -- D02"
' UNIT cell structure 2959
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2959 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2906
com="UNIT 2906 channel -- D03"
' UNIT cell structure 2906
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2906 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
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 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2992
com="UNIT 2992 channel -- D04"
' UNIT cell structure 2992
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2992 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2962
com="UNIT 2962 channel -- D05"
' UNIT cell structure 2962
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2962 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
```

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 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2928
com="UNIT 2928 channel -- D07"
' UNIT cell structure 2928
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2928 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2939
com="UNIT 2939 channel -- D08"
' UNIT cell structure 2939
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2939 1 64      -65 vol=385.42
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 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5918
com="UNIT 5918 channel -- D09"
' UNIT cell structure 5918
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5918 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2977
com="UNIT 2977 channel -- D10"
' UNIT cell structure 2977
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
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 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2977 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2974
com="UNIT 2974 channel -- D11"
' UNIT cell structure 2974
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2974 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2905
com="UNIT 2905 channel -- D12"
' UNIT cell structure 2905
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
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 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2905 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2943
com="UNIT 2943 channel -- D13"
' UNIT cell structure 2943
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2943 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2950
com="UNIT 2950 channel -- D15"
' UNIT cell structure 2950
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
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 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2950 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2929
com="UNIT 2929 channel -- D16"
' UNIT cell structure 2929
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2929 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2955
com="UNIT 2955 channel -- D17"
' UNIT cell structure 2955
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
```

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' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2955 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2975
com="UNIT 2975 channel -- D18"
' UNIT cell structure 2975
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2975 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5845
com="UNIT 5845 channel -- E01"
' UNIT cell structure 5845
 hexprism 30 2.177 32.309      -36.424
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 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5845 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6932
com="UNIT 6932 channel -- E02"
' UNIT cell structure 6932
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6932 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2932
```

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com="UNIT 2932 channel -- E03"
' UNIT cell structure 2932
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2932 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5915
com="UNIT 5915 channel -- E04"
' UNIT cell structure 5915
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5915 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
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 boundary 30

UNIT 6886
com="UNIT 6886 channel -- E05"
' UNIT cell structure 6886
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6886 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5912
com="UNIT 5912 channel -- E06"
' UNIT cell structure 5912
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5912 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
```

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 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5846
com="UNIT 5846 channel -- E07"
' UNIT cell structure 5846
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5846 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5903
com="UNIT 5903 channel -- E08"
' UNIT cell structure 5903
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5903 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
```

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 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5917
com="UNIT 5917 channel -- E09"
' UNIT cell structure 5917
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5917 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6929
com="UNIT 6929 channel -- E10"
' UNIT cell structure 6929
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6929 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
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' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6925
com="UNIT 6925 channel -- E12"
' UNIT cell structure 6925
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6925 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5844
com="UNIT 5844 channel -- E13"
' UNIT cell structure 5844
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5844 1 64      -65 vol=385.42
 media 5 1 40      -41
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 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6923
com="UNIT 6923 channel -- E14"
' UNIT cell structure 6923
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6923 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5919
com="UNIT 5919 channel -- E15"
' UNIT cell structure 5919
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
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' UNIT cell structure
 media 5919 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5921
com="UNIT 5921 channel -- E16"
' UNIT cell structure 5921
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5921 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6927
com="UNIT 6927 channel -- E17"
' UNIT cell structure 6927
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
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 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6927 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5902
com="UNIT 5902 channel -- E18"
' UNIT cell structure 5902
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5902 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5904
com="UNIT 5904 channel -- E19"
' UNIT cell structure 5904
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
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 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5904 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6930
com="UNIT 6930 channel -- E20"
' UNIT cell structure 6930
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6930 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6889
com="UNIT 6889 channel -- E21 "
' UNIT cell structure 6889
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
```

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 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6889 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5914
com="UNIT 5914 channel -- E22"
' UNIT cell structure 5914
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5914 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6142
com="UNIT 6142 channel -- E23"
' UNIT cell structure 6142
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
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 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6142 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6928
com="UNIT 6928 channel -- E24"
' UNIT cell structure 6928
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6928 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10817
com="UNIT 10817 channel -- F01"
```

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' UNIT cell structure 10817
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10817 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5911
com="UNIT 5911 channel -- F02"
' UNIT cell structure 5911
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5911 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30
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UNIT 3496
com="UNIT 3496 channel -- F03"
' UNIT cell structure 3496
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3496 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3504
com="UNIT 3504 channel -- F04"
' UNIT cell structure 3504
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3504 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
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 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3703
com="UNIT 3703 channel -- F05"
' UNIT cell structure 3703
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3703 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10816
com="UNIT 10816 channel -- F06"
' UNIT cell structure 10816
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10816 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
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 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2915
com="UNIT 2915 channel -- F07"
' UNIT cell structure 2915
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2915 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2946
com="UNIT 2946 channel -- F08"
' UNIT cell structure 2946
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2946 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
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 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6924
com="UNIT 6924 channel -- F09"
' UNIT cell structure 6924
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6924 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10812
com="UNIT 10812 channel -- F10"
' UNIT cell structure 10812
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10812 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
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 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2958
com="UNIT 2958 channel -- F11"
' UNIT cell structure 2958
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2958 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5913
com="UNIT 5913 channel -- F12"
' UNIT cell structure 5913
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
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 media 5913 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2902
com="UNIT 2902 channel -- F15"
' UNIT cell structure 2902
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2902 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10813
com="UNIT 10813 channel -- F16"
' UNIT cell structure 10813
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
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 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10813 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2912
com="UNIT 2912 channel -- F17"
' UNIT cell structure 2912
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2912 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6143
com="UNIT 6143 channel -- F18"
' UNIT cell structure 6143
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
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 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6143 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5916
com="UNIT 5916 channel -- F19"
' UNIT cell structure 5916
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5916 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2940
com="UNIT 2940 channel -- F20"
' UNIT cell structure 2940
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
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 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2940 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2971
com="UNIT 2971 channel -- F21"
' UNIT cell structure 2971
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2971 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2969
com="UNIT 2969 channel -- F22"
' UNIT cell structure 2969
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
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 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2969 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6926
com="UNIT 6926 channel -- F23"
' UNIT cell structure 6926
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6926 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3513
com="UNIT 3513 channel -- F24"
' UNIT cell structure 3513
```

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 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3513 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10811
com="UNIT 10811 channel -- F25"
' UNIT cell structure 10811
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10811 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30
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UNIT 2960
com="UNIT 2960 channel -- F26"
' UNIT cell structure 2960
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2960 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2947
com="UNIT 2947 channel -- F27"
' UNIT cell structure 2947
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2947 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
```

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 media 3 1 68
 boundary 30

UNIT 2911
com="UNIT 2911 channel -- F28"
' UNIT cell structure 2911
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2911 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5922
com="UNIT 5922 channel F-29"
' UNIT cell structure 5922
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5922 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
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 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10814
com="UNIT 10814 channel -- F30"
' UNIT cell structure 10814
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10814 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10704
com="UNIT 10704 channel -- G02"
' UNIT cell structure 10704
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10704 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
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 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2908
com="UNIT 2908 channel -- G03"
' UNIT cell structure 2908
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2908 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 3700
com="UNIT 3700 channel -- G04"
' UNIT cell structure 3700
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 3700 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
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 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 6931
com="UNIT 6931 channel -- G05"
' UNIT cell structure 6931
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 6931 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 5920
com="UNIT 5920 channel -- G06"
' UNIT cell structure 5920
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 5920 1 64      -65 vol=385.42
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 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10701
com="UNIT 10701 channel -- G08"
' UNIT cell structure 10701
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10701 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2957
com="UNIT 2957 channel -- G09"
' UNIT cell structure 2957
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
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 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2957 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2938
com="UNIT 2938 channel -- G10"
' UNIT cell structure 2938
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2938 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2927
com="UNIT 2927 channel -- G11"
' UNIT cell structure 2927
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
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 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2927 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10702
com="UNIT 10702 channel -- G12"
' UNIT cell structure 10702
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10702 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2970
com="UNIT 2970 channel -- G14"
' UNIT cell structure 2970
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
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 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2970 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2976
com="UNIT 2976 channel G15"
' UNIT cell structure 2976
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2976 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2952
com="UNIT 2952 channel -- G16"
' UNIT cell structure 2952
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
```

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' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2952 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10815
com="UNIT 10815 channel -- G17"
' UNIT cell structure 10815
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10815 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2904
com="UNIT 2904 channel -- G18"
' UNIT cell structure 2904
 hexprism 30 2.177 32.309      -36.424
```

```
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2904 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2968
com="UNIT 2968 channel -- G20"
' UNIT cell structure 2968
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2968 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2903
```

```
com="UNIT 2903 channel -- G21"
' UNIT cell structure 2903
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2903 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2935
com="UNIT 2935 channel -- G22"
' UNIT cell structure 2935
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2935 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
```

```
 boundary 30

UNIT 2930
com="UNIT 2930 channel -- G23"
' UNIT cell structure 2930
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2930 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2951
com="UNIT 2951 channel -- G24"
' UNIT cell structure 2951
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2951 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
```

```
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10699
com="UNIT 10699 channel -- G26"
' UNIT cell structure 10699
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10699 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2948
com="UNIT 2948 channel -- G27"
' UNIT cell structure 2948
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2948 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
```

```
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2913
com="UNIT 2913 channel -- G28"
' UNIT cell structure 2913
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2913 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2954
com="UNIT 2954 channel -- G29"
' UNIT cell structure 2954
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2954 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
```

```
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10700
com="UNIT 10700 channel  -- G30"
' UNIT cell structure 10700
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10700 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 2918
com="UNIT 2918 channel -- G33"
' UNIT cell structure 2918
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 2918 1 64      -65 vol=385.42
 media 5 1 40      -41
```

```
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10810
com="UNIT 10810 channel -- G35"
' UNIT cell structure 10810
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
' UNIT cell structure
 media 10810 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30

UNIT 10703
com="UNIT 10703 channel -- 36"
' UNIT cell structure 10703
 hexprism 30 2.177 32.309      -36.424
 hexprism 40 2.177 32.309      30.734
 cylinder 41 1.911 32.309      -36.424
 hexprism 50 2.177 -33.249      -36.424
' fuel element
 cone 60 0.635 32.537      1.8771 27.4574
 cylinder 61 1.8771 27.4574      -28.5013
 cylinder 62 1.8263 26.8224      -27.8663
 cylinder 63 1.7183 25.5524      19.05
 cylinder 64 1.8225 19.05      -19.05
 cylinder 65 0.3175 19.05      -19.05
 cylinder 66 1.7183 -19.05      -19.1287
 cylinder 67 1.7183 -19.1287      -27.8663
 cone 68 1.8771 -28.5013      0.635 -34.775
```

```
' UNIT cell structure
 media 10703 1 64      -65 vol=385.42
 media 5 1 40      -41
 media 5 1 50      -41
 media 2 1 30      -40 -41 -50
 media 2 1 41      -60 -61 -68
' fuel element
 media 3 1 60
 media 3 1 61      -62
 media 0 1 62      -63 -64 -66 -67
 media 4 1 63
 media 1 1 65
 media 9 1 66
 media 4 1 67
 media 3 1 68
 boundary 30
UNIT 10147
com="UNIT 10147: shim 1"
com=" like UNIT 3 with FFCR in the penetration"
com=" cladding (60, -61, -62, -63, -64, -65, -67) CELL DATA"
com=" NOTE: end fittings and weld plugs included in cladding"
com=" upper air gap  (61) - 6 "
com=" posion air gap (62) - 6 "
com=" B4C posion     (63) - 7 "
com=" fuel air gap   (64) - 8 "
com=" fuel           (65)                    CELL DATA"
com=" zir fill rod   (66)                     CELL DATA"
com=" air follower   (67)"
'
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
 hexprism 50    2.177  -33.249  -36.424
'
 CYLINDER 60    1.715   41.58    -74.613   origin  x=0 y=0 z=19.05
 CYLINDER 61    1.664   34.460    25.570   origin  x=0 y=0 z=19.05
 CYLINDER 62    1.664   22.530    22.225   origin  x=0 y=0 z=19.05
 CYLINDER 63    1.664   22.225   -15.875   origin  x=0 y=0 z=19.05
 CYLINDER 64    1.664  -18.415   -19.050   origin  x=0 y=0 z=19.05
 CYLINDER 65    1.664  -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 66    0.3175 -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 67    1.499  -59.69    -73.343   origin  x=0 y=0 z=19.05
' UNIT cell structure   10148
 media  10147 1 65 -66                    vol=319.24
 media    5  1 40 -41
 media    5  1 50 -41
 media    2  1 30 -40 -41 -50
 media    2  1 41 -60
' FFCR
 media    3  1 60 -61 -62 -63 -64 -65 -67
 media    0  1 61
 media    0  1 62
 media    7  1 63
 media    8  1 64
 media    1  1 66
 media    6  1 67
 boundary 30
'
UNIT 10148
com="UNIT 10148: shim 2"
com=" same as UNIT 5"
'
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
```

```
 hexprism 50    2.177  -33.249  -36.424
'
 CYLINDER 60    1.715   41.58    -74.613   origin  x=0 y=0 z=19.05
 CYLINDER 61    1.664   34.460    25.570   origin  x=0 y=0 z=19.05
 CYLINDER 62    1.664   22.530    22.225   origin  x=0 y=0 z=19.05
 CYLINDER 63    1.664   22.225   -15.875   origin  x=0 y=0 z=19.05
 CYLINDER 64    1.664  -18.415   -19.050   origin  x=0 y=0 z=19.05
 CYLINDER 65    1.664  -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 66    0.3175 -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 67    1.499  -59.69    -73.343   origin  x=0 y=0 z=19.05
' UNIT cell structure   10147
 media  10148   1 65 -66                    vol=319.24
 media    5  1 40 -41
 media    5  1 50 -41
 media    2  1 30 -40 -41 -50
 media    2  1 41 -60
' FFCR
 media    3  1 60 -61 -62 -63 -64 -65 -67
 media    0  1 61
 media    0  1 62
 media    7  1 63
 media    8  1 64
 media    1  1 66
 media    6  1 67
 boundary 30
'
UNIT 10146
com="UNIT 10146: reg rod"
com=" same as UNIT 5"
'
 hexprism 30    2.177   32.309  -36.424
 hexprism 40    2.177   32.309   30.734
 cylinder 41    1.911   32.309  -36.424
 hexprism 50    2.177  -33.249  -36.424
'
 CYLINDER 60    1.715   41.58    -74.613   origin  x=0 y=0 z=19.05
 CYLINDER 61    1.664   34.460    25.570   origin  x=0 y=0 z=19.05
 CYLINDER 62    1.664   22.530    22.225   origin  x=0 y=0 z=19.05
 CYLINDER 63    1.664   22.225   -15.875   origin  x=0 y=0 z=19.05
 CYLINDER 64    1.664  -18.415   -19.050   origin  x=0 y=0 z=19.05
 CYLINDER 65    1.664  -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 66    0.3175 -19.050   -57.15    origin  x=0 y=0 z=19.05
 CYLINDER 67    1.499  -59.69    -73.343   origin  x=0 y=0 z=19.05
' UNIT cell structure   10146
 media  10146   1 65 -66                    vol=319.24
 media    5  1 40 -41
 media    5  1 50 -41
 media    2  1 30 -40 -41 -50
 media    2  1 41 -60
' FFCR
 media    3  1 60 -61 -62 -63 -64 -65 -67
 media    0  1 61
 media    0  1 62
 media    7  1 63
 media    8  1 64
 media    1  1 66
 media    6  1 67
 boundary 30
'
end geometry
read array
ara=1 nux=15 nuy=15 nuz=1 typ=shexagonal
 fill
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 5920 6931 3700 2908 10704 2 2 2 2 2
```

```
2 2 2 2 10701 10816 3703 3504 3496 5911 10817 10703 2 2 2
2 2 2 2957 2915 6886 5915 2932 6932 5845 10814 10810 2 2 2
2 2 2 2938 2946 5912 2992 2906 2959 2910 6928 5922 3 2 2
2 2 2927 6924 5846 2962 2984 2965 8 2975 6142 2947 2918 2 2
2 2 10702 10812 5903 10147 2944 3384 2985 2964 2955 5914 2911 3 2
2 2 2958 5917 2928 2931 10878 3 10809 2979 2929 6889 2960 2 2
2 2 2970 5913 6929 2939 2983 3013 2899 2941 2950 6930 10811 10700 2
2 2 2976 3 3 5918 10146 2980 2925 10148 5904 3513 2954 2 2
2 2 2 2952 3 6925 2977 2974 2905 2943 5902 6926 2913 2 2
2 2 2 10815 2902 5844 6923 5919 5921 6927 2969 2948 2 2 2
2 2 2 2 2904 10813 2912 6143 5916 2940 2971 10699 2 2 2
2 2 2 2 2 2968 2903 2935 2930 2951 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   end fill
end array
end data
end model
end
=shell
 cp ft33f001.mix0015 ${DATA}/arplibs/triga_3el_26Feb19.f33
 cp ft33f001.mix0015 ${DATA}/arplibs/triga_3el_26Feb19.arplib
 cp ft33f001.cmbined ${DATA}/arplibs/triga_3el_2_26Feb19.f33
 cp ft33f001.cmbined ${DATA}/arplibs/triga_3el_2_26Feb19.arplib
 cp ft33f001.mix0015 "${INPDIR}/TRIGATRIGATRIGA_123.f33"
end
```

COUPLE—ORIGEN MODULE INPUT FILES

```
=couple
*********************************************************************************
*       this is a practice couple input file ---> a testers!              *
*********************************************************************************

0$$ a3 80 a6 33 e
' Use JEFF-238 group (a3=80), and output to standard library number (a6=33)
1$$ a1 0 a2 0 a3 0 a7 3 a9 19 a15 5 a18 238 e t
' Set the date (a7-9)=Aug 2018,
' Copy 8 title lines from input library (a16=8),
' and read in 238 groups for the flux.
7$$ 922330 922350 922380 942390 942410 e
' The above is setting the fission nuclides according to a15 in 1$$
' TRIGA modified fast flux spectrum (238group endf/b-vii)
9**
6.350000E-10  1.130000E-09  9.560000E-10  1.440000E-09  2.170000E-09
3.780000E-08  1.130000E-07  4.230000E-07  1.280000E-06  1.440000E-06
2.870000E-06  4.110000E-06  2.330000E-06  3.200000E-06  5.060000E-06
3.220000E-06  1.170000E-06  6.560000E-07  8.250000E-07  1.000000E-06
1.430000E-06  1.810000E-06  1.730000E-06  1.120000E-06  5.300000E-07
4.450000E-07  6.940000E-07  1.520000E-06  1.970000E-06  1.110000E-06
1.140000E-06  1.410000E-06  7.230000E-07  1.130000E-06  1.240000E-06
8.740000E-07  6.900000E-07  5.730000E-07  1.590000E-06  2.490000E-06
2.760000E-06  2.830000E-06  1.950000E-06  1.570000E-06  1.340000E-06
5.480000E-07  4.110000E-07  3.940000E-07  6.290000E-07  9.030000E-07
4.610000E-07  3.360000E-07  1.060000E-06  1.180000E-06  1.010000E-06
1.050000E-06  8.140000E-07  6.130000E-07  5.140000E-07  6.940000E-07
4.190000E-07  1.810000E-07  2.340000E-07  1.530000E-07  8.890000E-08
1.210000E-07  1.650000E-07  7.640000E-08  1.040000E-07  1.450000E-07
1.210000E-07  7.180000E-08  3.410000E-08  8.220000E-08  5.450000E-08
1.090000E-08  1.170000E-08  4.580000E-09  1.970000E-09  2.330000E-09
4.930000E-09  4.450000E-09  2.110000E-10  4.880000E-10  5.920000E-10
5.370000E-10  4.310000E-10  1.910000E-10  2.170000E-10  1.970000E-10
1.130000E-10  1.230000E-10  1.250000E-10  7.670000E-11  8.420000E-11
9.470000E-11  3.090000E-11  4.930000E-11  3.180000E-11  8.800000E-12
7.370000E-12  4.090000E-12  5.750000E-12  1.650000E-12  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  2.210000E-13
2.210000E-13  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
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0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
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0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
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0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
```

```
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00
E T
done
end
' that is apparently it, now we generate the ft33 files to import into ORIGEN
' below is the shell command to copy the ft33 file and retain it
' inputing dir before copying outputs the exact directory to where the file
' is being copied.
=shell
   dir
   copy ft33f001 "${INPDIR}/TRIGA_act.f33"
end
```

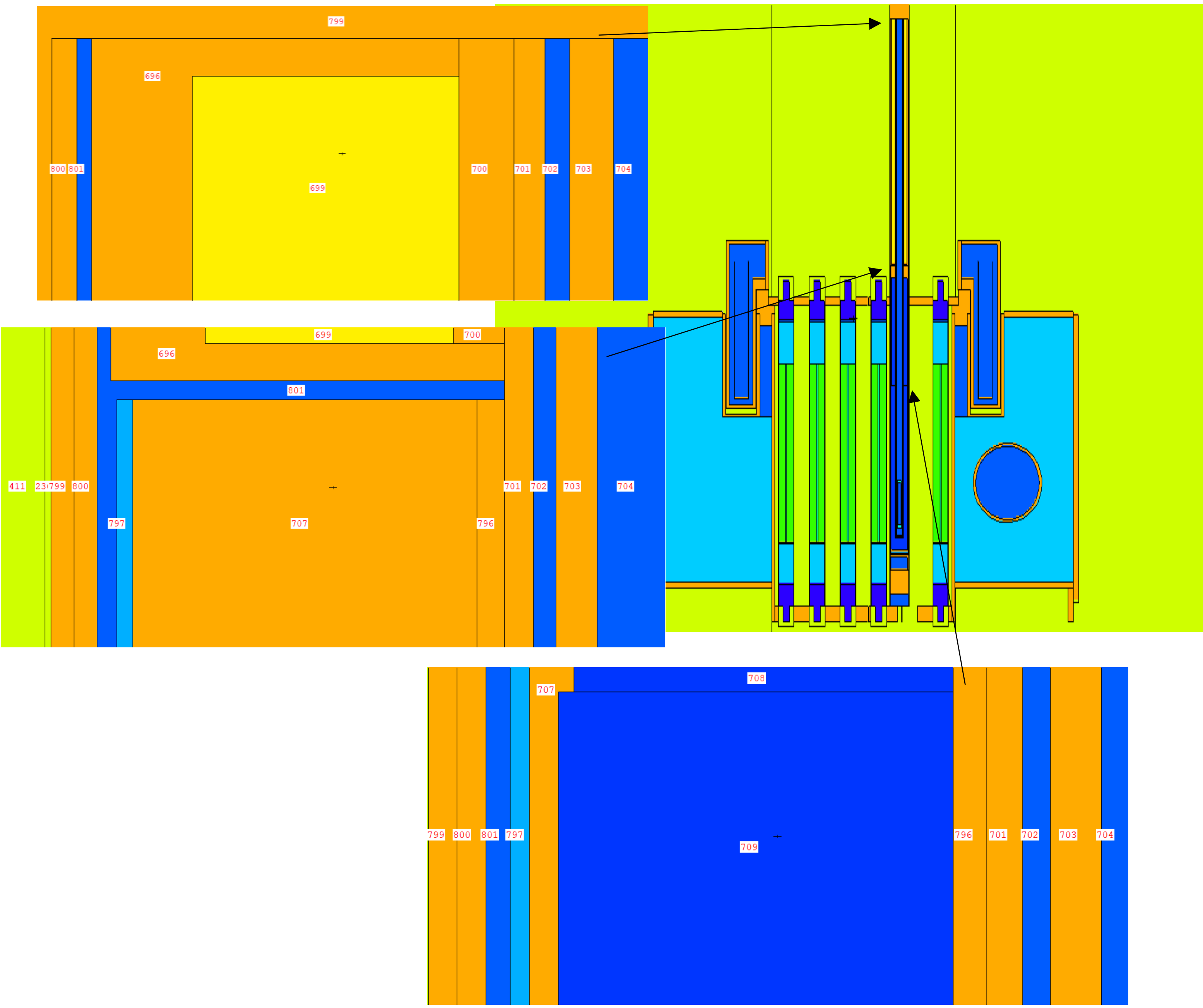
```
=origen
 % Activation of all the elements we might see in an irradiation study after
 % 60 seconds of irradiation in a flux specified by an f33 transformation
 % matrix file.

 % Choose the solver type. Since CRAM seems to be most flexible, I'll use that.
  solver{
    type=CRAM  %MATREX
    opt{
 %terms=21        %maxp=150
      order=16   % Order of method (default=16)
 % 2-4 substeps results in large accuracy gain with marginal runtime increase (pg 691)
      substeps=3 % Number time step divisions (default=1).
    }
  }

  options{
    print_xs=yes           % Output transition matrix x-sections
    digits=6               % high-precision with digits=6, 4 is standard
    fixed_fission_energy=no % fixed fission energy is 200 MeV/fission
  }

  bounds{
  neutron="origen.rev03.jeff238g" % 238-group structure read from JEFF library
                         % used in COUPLE
  alpha  = [9I 2e7 2e3]          % 10 linearly spaced bins, 20MeV-2keV
  beta   = [9I 2e7 2e3]          % 10 linearly spaced bins, 20MeV-2keV
  gamma  = [9L 5.0e7 5.0e-5]      % 10 logarithmically spaced bins
  }

% ============================== Irradiation ============================= %
  case(irr){
    title="10s Irradiation #1"

'    Input the following libs (with the following fluxes (lib:flux):
'    TRIGA_act.f33 : 2E12

    lib{ file="${INPDIR}/TRIGA_act.f33"} % library to use in irradiation
    mat{ units="GRAMS"   iso=[094239=123.45] } % selection of material to irradiate

    time ={start = 0 t=[1 3 5 7 9 10] units=seconds} % Irradiation time in seconds
'     time ={t=[1 3 5 7 9 10] units=seconds} % Irradiation time in seconds
'     power=[6R 0.950] % total power in the TRIGA 3-EL facility
    flux =[6R 2E12]  % total flux in the TRIGA 3-EL facility

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}
```

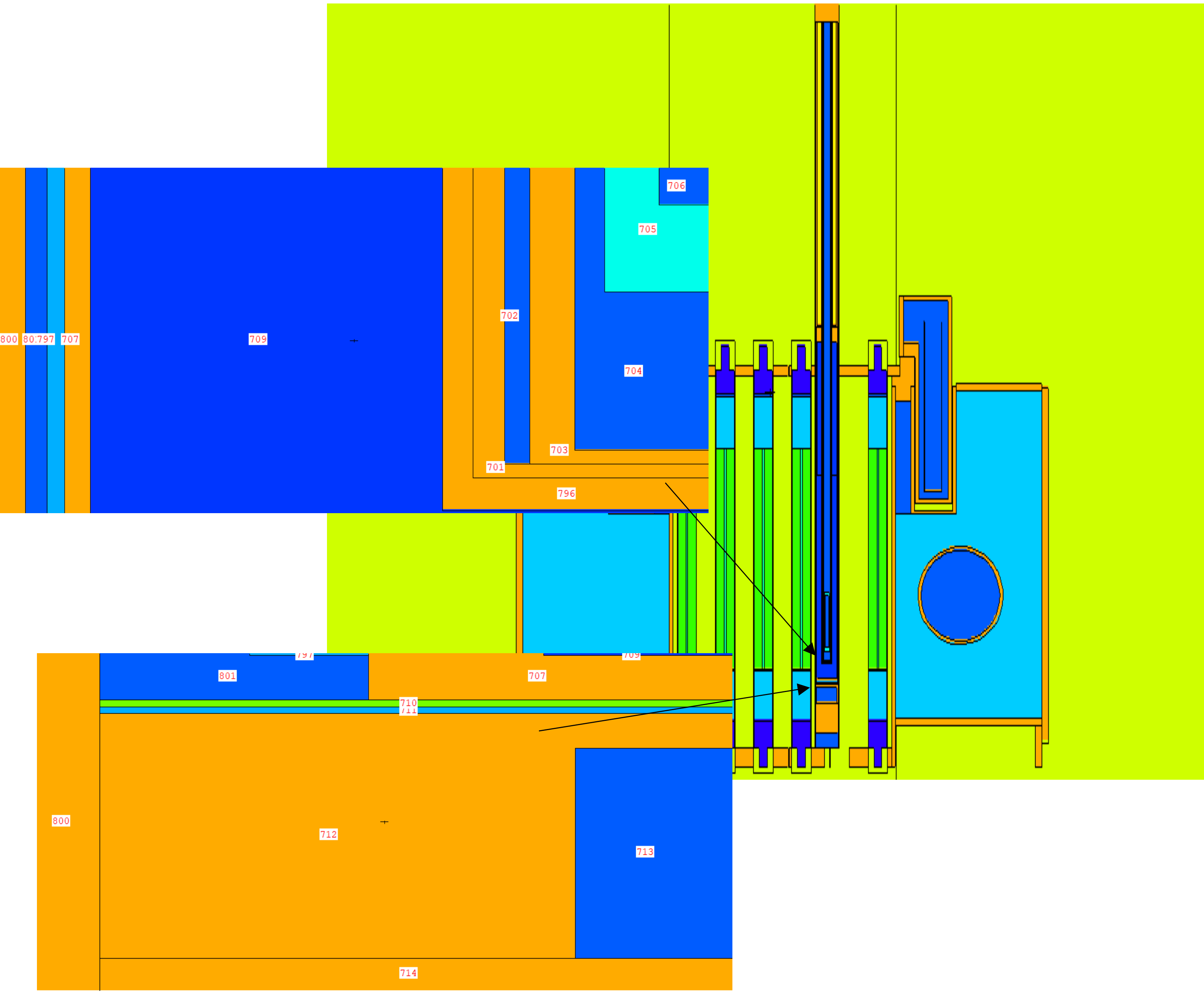
```
    absfrac_sublib = ALL %print absorption fractions for
                     %a specific sublib (LT,AC,FP)
                     %or ALL sublibs (DEFAULT)
    absfrac_step = 6     %if absfrac active, step to print
                     % default is last step
    fisrate = ABS       %print fission rates (default NONE)
                     %absolute (ABS) or relative (REL)
    kinf = YES          %print fission/absorption (yes/no)
       }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
      neutron=yes
  } % End Irradiation Case #1

% -------------------------------- Decay -------------------------------- %
  case(dec){
    title="10 min Decay #1"

    mat{
      load{ file="PU239_con_25Mar19.f71" pos=2}
    }
    % Cool-down for 10 minutes
    time ={
'     start = 10
      t=[11 100 200 300 350 400 500 600 610] units=seconds
         } % Irradiation time in seconds
'      power =[9R 0] % 0 power means decay only
    flux =[9R 0] % 0 flux means decay only

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS CURIES] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}
    }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
    neutron=yes
    beta=yes    % only option: pick sublibs. Like alpha, for source determination (no physics)
    gamma=yes   % defaults are generally appropriate, with exceptions noted on p731
  } % End Cool-Down Case
% ============================== Irradiation ============================= %
  case(irr){
    title="10s Irradiation #2"

'   Input the following libs (with the following fluxes (lib:flux):
'   TRIGA_act.f33 : 2E12

    lib{ file="${INPDIR}/TRIGA_act.f33"} % library to use in irradiation
    mat{ units="GRAMS"   iso=[094239=123.45] } % selection of material to irradiate

'   time ={start = 610 t=[611 613 615 617 619 620] units=seconds} % Irradiation time in seconds
    time ={ t=[611 613 615 617 619 620] units=seconds} % Irradiation time in seconds || start = 0
'   power=[6R 0.950] % total power in the TRIGA 3-EL facility
    flux =[6R 2E12]  % total flux in the TRIGA 3-EL facility

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}
```

```
    absfrac_sublib = ALL %print absorption fractions for
                     %a specific sublib (LT,AC,FP)
                     %or ALL sublibs (DEFAULT)
    absfrac_step = 6     %if absfrac active, step to print
                     % default is last step
    fisrate = ABS        %print fission rates (default NONE)
                     %absolute (ABS) or relative (REL)
    kinf = YES          %print fission/absorption (yes/no)
        }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
      neutron=yes
  } % End Irradiation Case #2
% -------------------------------- Decay -------------------------------- %
  case(dec){
    title="10 min Decay #2"

    mat{
      load{ file="PU239_con_25Mar19.f71" pos=4}
    }
    % Cool-down for 10 minutes
    time ={
'     start = 620
      t=[621 675 800 900 1000 1050 1100 1200 1220] units=seconds
        } % Irradiation time in seconds
'       power =[9R 0] % 0 power means decay only
     flux =[9R 0] % 0 flux means decay only

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS CURIES] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}
    }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
    neutron=yes
    beta=yes    % only option: pick sublibs. Like alpha, for source determination (no physics)
    gamma=yes   % defaults are generally appropriate, with exceptions noted on p731
  } % End Cool-Down Case

% ============================== Irradiation ============================= %
  case(irr){
    title="10s Irradiation #3"

'   Input the following libs (with the following fluxes (lib:flux):
'   TRIGA_act.f33 : 2E12

    lib{ file="${INPDIR}/TRIGA_act.f33"} % library to use in irradiation
    mat{ units="GRAMS"   iso=[094239=123.45] } % selection of material to irradiate

'   time ={start = 610 t=[611 613 615 617 619 620] units=seconds} % Irradiation time in seconds
    time ={ t=[1221 1223 1225 1227 1229 1230] units=seconds} % Irradiation time in seconds || start = 0
'   power=[6R 0.950] % total power in the TRIGA 3-EL facility
    flux =[6R 2E12]  % total flux in the TRIGA 3-EL facility

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}

    absfrac_sublib = ALL %print absorption fractions for
```

```
                  %a specific sublib (LT,AC,FP)
                  %or ALL sublibs (DEFAULT)
    absfrac_step = 6     %if absfrac active, step to print
                  % default is last step
    fisrate = ABS       %print fission rates (default NONE)
                  %absolute (ABS) or relative (REL)
    kinf = YES          %print fission/absorption (yes/no)
        }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
      neutron=yes
  } % End Irradiation Case #3
% -------------------------------- Decay -------------------------------- %
  case(dec){
    title="10 min Decay #3"

    mat{
      load{ file="PU239_con_25Mar19.f71" pos=4}
    }
    % Cool-down for 10 minutes
    time ={
'      start = 620
       t=[1231 1330 1430 1530 1600 1700 1750 1800 1830] units=seconds
          } % Irradiation time in seconds
'       power =[9R 0] % 0 power means decay only
      flux =[9R 0] % 0 flux means decay only

    print{
      nuc{ total=yes units=[GRAMS BECQUERELS CURIES] }
      cutoffs=[GRAMS=1E-12]
      neutron{spectra=yes}
    }
    save{
      file="PU239_con_25Mar19.f71"
      steps=ALL
    }
    neutron=yes
    beta=yes    % only option: pick sublibs. Like alpha, for source determination (no physics)
    gamma=yes   % defaults are generally appropriate, with exceptions noted on p731
  } % End Cool-Down Case


end

' List out the contents of the running temp directory. It's not possible to copy the .f71 files
' because they sit in the temp directly until SCALE stops running, so no matter what you'll have
' these files in your ${INPDIR}.
=shell
  Dir
```

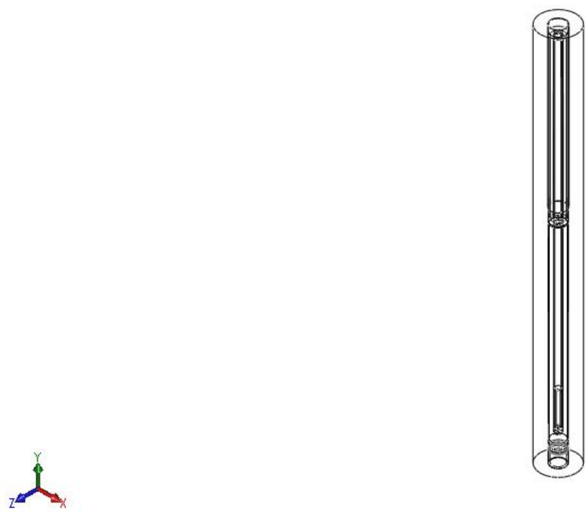
EXCEL CALCULATIONS, CELL REFERENCES




706
705
702
800
80:797
707
709
704
703
701
796
797
709
801
707
710
711
800
712
713
714

SolidWorks Thermal Simulation Report

Model Information

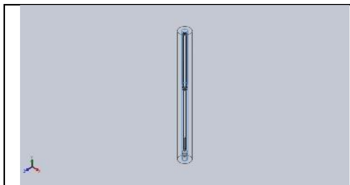
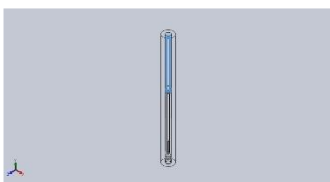
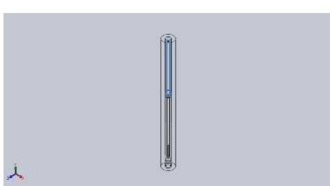


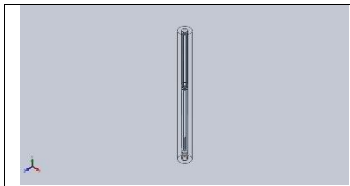
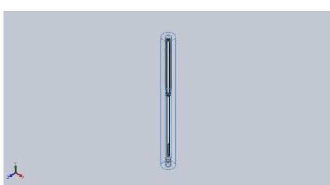
Model name: **19Apr19_SWmodel_hopefully_lastONE**

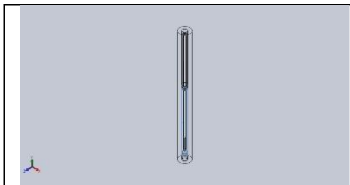
Current Configuration: **Default**

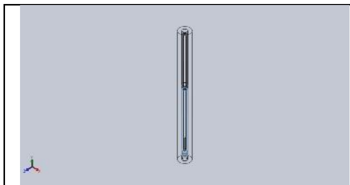
Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Boss-Extrude2 	**Solid Body**	Mass:0.037525 kg Volume:1.38981e-05 m^3 Density:2700 kg/m^3 Weight:0.367745 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al cap.SLDPRT **Apr 21 01:10:19 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.0359988 kg Volume:1.33329e-05 m^3 Density:2700 kg/m^3 Weight:0.352789 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al spacer with cd and silver disks.SLDPRT **Apr 21 01:10:20 2019**
Boss-Extrude2	**Solid Body**	Mass:0.0135614 kg	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al spacer with cd and silver disks.SLDPRT

		Volume:1.56779e-06 m^3 Density:8650 kg/m^3 Weight:0.132902 N	**Apr 21 01:10:20 2019**
Boss-Extrude5 	**Solid Body**	Mass:0.0172457 kg Volume:1.56779e-06 m^3 Density:11000 kg/m^3 Weight:0.169008 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al spacer with cd and silver disks.SLDPRT **Apr 21 01:10:20 2019**
Cut-Extrude2 	**Solid Body**	Mass:0.494781 kg Volume:0.000183252 m^3 Density:2700 kg/m^3 Weight:4.84885 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al tube for 3-EL.SLDPRT **Apr 21 01:10:20 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.189755 kg Volume:7.02797e-05 m^3 Density:2700 kg/m^3 Weight:1.8596 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al-can lateral portion.SLDPRT **Apr 21 01:10:20 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.0860502 kg Volume:3.18704e-05 m^3 Density:2700 kg/m^3 Weight:0.843292 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Al-can pneumatic sleeve and top portion.SLDPRT **Apr 21 01:10:20 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.342997 kg Volume:3.96528e-05 m^3 Density:8650 kg/m^3 Weight:3.36137 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\Cd-sleeve.SLDPRT **Apr 21 01:10:21 2019**
Boss-Extrude1	**Solid Body**	Mass:0.000152952 kg	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\air in inner al tube.SLDPRT

		Volume:0.000139047 m^3 Density:1.1 kg/m^3 Weight:0.00149893 N	**Apr 21 01:10:22 2019**
Cut-Extrude2 	**Solid Body**	Mass:0.63684 kg Volume:0.000235867 m^3 Density:2700 kg/m^3 Weight:6.24103 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\al can for b4c.SLDPRT **Apr 21 01:10:19 2019**
Boss-Extrude2 	**Solid Body**	Mass:0.899432 kg Volume:0.000642451 m^3 Density:1400 kg/m^3 Weight:8.81443 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\b-10 powder.SLDPRT **Apr 22 12:34:14 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.55785 kg Volume:0.000382089 m^3 Density:1460 kg/m^3 Weight:5.46693 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\boron carbide.SLDPRT **Apr 21 01:10:20 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.171622 kg Volume:6.35635e-05 m^3 Density:2700 kg/m^3 Weight:1.68189 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\inner pneumatic tube.SLDPRT **Apr 21 01:10:21 2019**
Cut-Extrude1 	**Solid Body**	Mass:0.175847 kg Volume:6.51284e-05 m^3 Density:2700 kg/m^3 Weight:1.7233 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\pneumatic system.SLDPRT **Apr 21 01:10:21 2019**
Cut-Extrude1	**Solid Body**	Mass:0.0193565 kg	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\quartz sample.SLDPRT

		Volume:7.87619e-06 m^3 Density:2457.6 kg/m^3 Weight:0.189694 N	**Apr 21 01:10:21 2019**
Boss-Extrude1[1] 	**Solid Body**	Mass:0.0179269 kg Volume:7.29446e-06 m^3 Density:2457.6 kg/m^3 Weight:0.175683 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\sample inside quartz.SLDPRT **Apr 22 14:25:02 2019**
Cut-Extrude2 	**Solid Body**	Mass:10.5267 kg Volume:0.0105267 m^3 Density:1000 kg/m^3 Weight:103.162 N	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\water.SLDPRT **Apr 21 01:10:21 2019**
Shell Bodies			
Document Name and Reference	Formulation	Volumetric Properties	Document Path/Date Modified
Shell-1 	**Thin**	Thickness:0.4953 mm Weight:0.000781226 N Volume:7.247e-05 m^3 Mass:7.9717e-05 kg **Density:1.1kg/m^3**	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\air around upper al canister.SLDPRT **Apr 21 01:10:22 2019**
Shell-2 	**Thin**	Thickness:0.2413 mm Weight:0.000456206 N Volume:4.23197e-05 m^3 Mass:4.65517e-05 kg **Density:1.1kg/m^3**	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\air around lower al canister.SLDPRT **Apr 21 01:10:21 2019**
Shell-3	**Thin**	Thickness:0.6985 mm Weight:0.000866368 N Volume:8.03681e-05 m^3 Mass:8.84049e-05 kg	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\air between pneumatic tubes.SLDPRT **Apr 21 01:10:22 2019**

		**Density:1.1kg/m^3**	
Shell-4 	**Thin**	Thickness:0.19304 mm Weight:1.97164e-05 N Volume:1.82898e-06 m^3 Mass:2.01188e-06 kg **Density:1.1kg/m^3**	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\air around quartz sample.SLDPRT **Apr 21 01:10:22 2019**

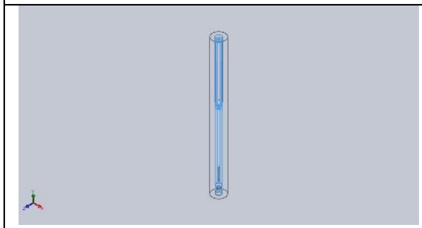
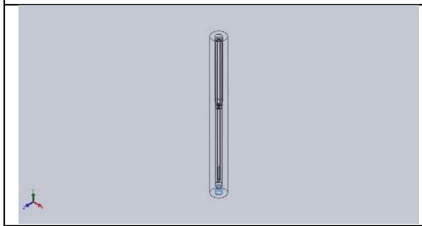
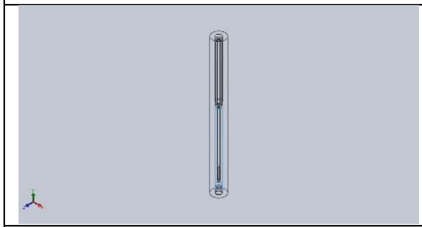
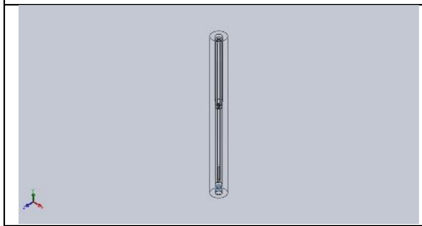
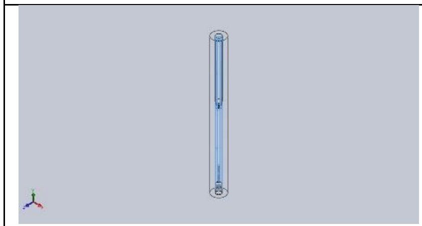
STUDY PROPERTIES

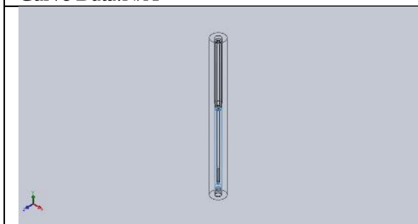
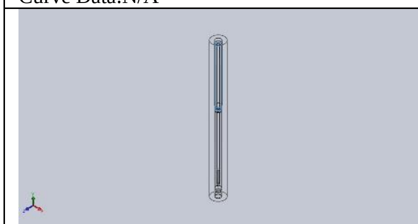
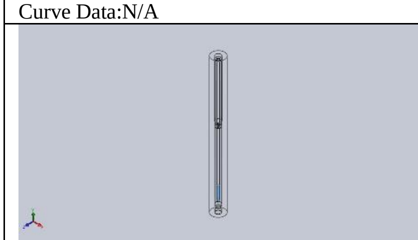
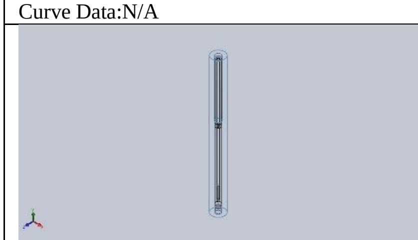
Study name	Thermal 1
Analysis type	Thermal(Steady state)
Mesh type	Mixed Mesh
Solver type	FFEPlus
Solution type	Steady state
Contact resistance defined?	No
Result folder	SOLIDWORKS document (c:\users\bad2284\appdata\local\temp)

UNITS

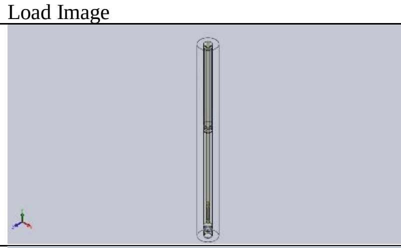
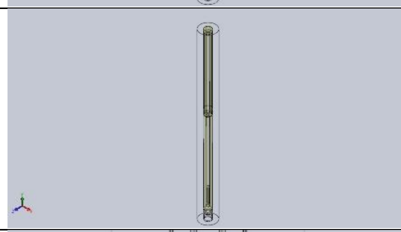
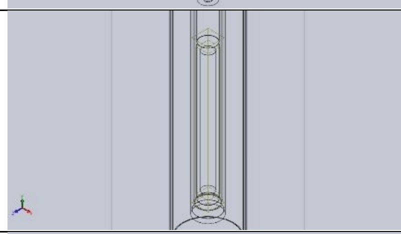
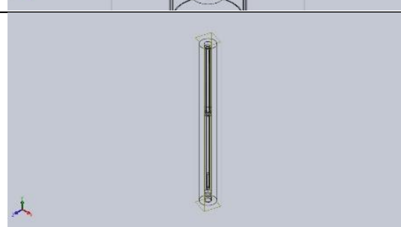
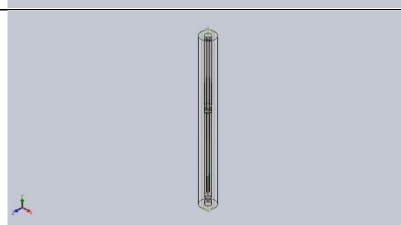
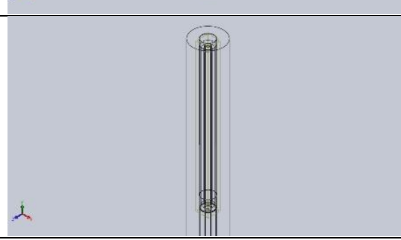
Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

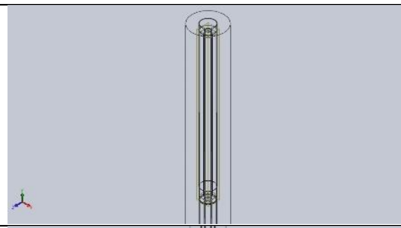
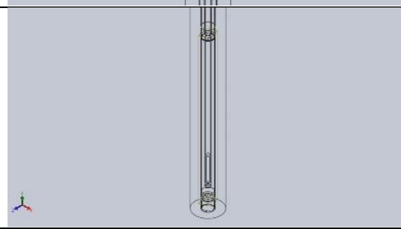
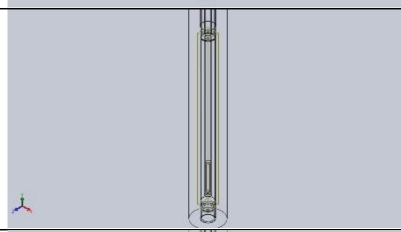
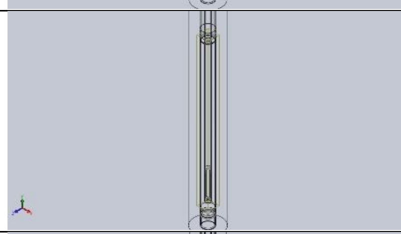
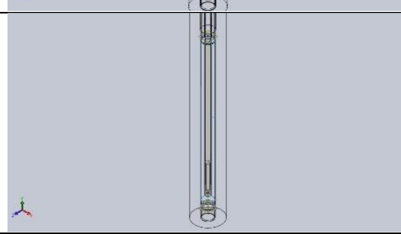
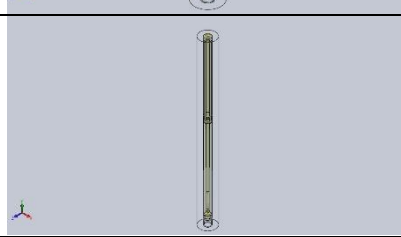
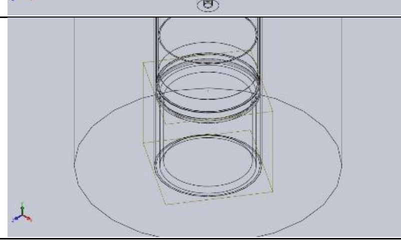
MATERIAL PROPERTIES

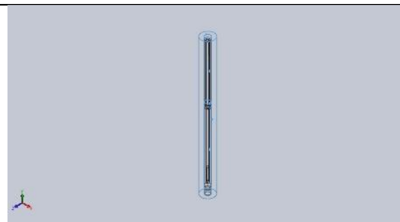
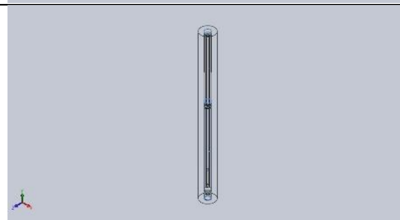
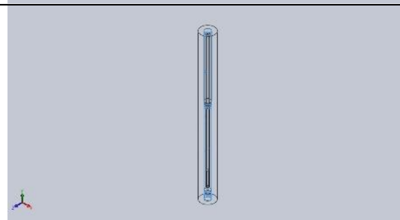
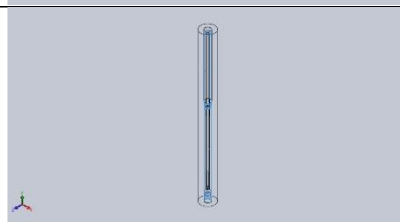
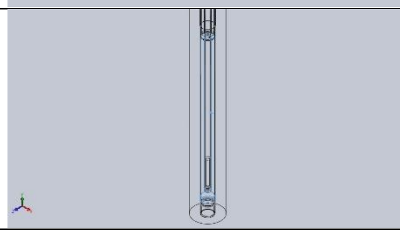
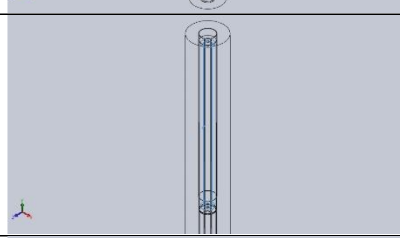
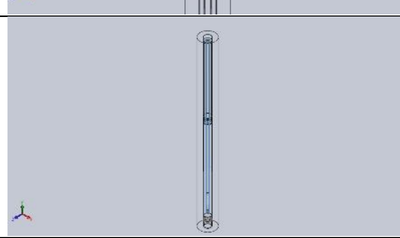
Model Reference	Properties	Components
	**Name:** 6061-T6 (SS) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 166.9 W/(m.K) **Specific heat:** 896 J/(kg.K) **Mass density:** 2700 kg/m^3	SolidBody 1(Boss-Extrude2)(Al cap-1), SolidBody 1(Cut-Extrude2)(Al tube for 3-EL-1), SolidBody 1(Cut-Extrude1)(Al-can lateral portion-1), SolidBody 1(Cut-Extrude1)(Al-can pneumatic sleeve and top portion-1), SolidBody 1(Cut-Extrude2)(al can for b4c-1), SolidBody 1(Cut-Extrude1)(inner pneumatic tube-1), SolidBody 1(Cut-Extrude1)(pneumatic system-1)
Curve Data:N/A		
	**Name:** 6061-T6 (SS) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 166.9 W/(m.K) **Specific heat:** 896 J/(kg.K) **Mass density:** 2700 kg/m^3	SolidBody 1(Cut-Extrude1)(Al spacer with cd and silver disks-1)
Curve Data:N/A		
	**Name:** Cadmium **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 97.7 W/(m.K) **Specific heat:** 230 J/(kg.K) **Mass density:** 8650 kg/m^3	SolidBody 2(Boss-Extrude2)(Al spacer with cd and silver disks-1), SolidBody 1(Cut-Extrude1)(Cd-sleeve-1)
Curve Data:N/A		
	**Name:** Pure Silver **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 420 W/(m.K) **Specific heat:** 230 J/(kg.K) **Mass density:** 11000 kg/m^3	SolidBody 3(Boss-Extrude5)(Al spacer with cd and silver disks-1)
Curve Data:N/A		
	**Name:** Air **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 0.027 W/(m.K) **Specific heat:** 1000 J/(kg.K) **Mass density:** 1.1 kg/m^3	SolidBody 1(Cut-Extrude1)(air around lower al canister-1), SolidBody 1(Cut-Extrude1)(air around quartz sample-1), SolidBody 1(Cut-Extrude1)(air around upper al canister-1), SolidBody 1(Cut-Extrude1)(air between pneumatic tubes-1), SolidBody 1(Boss-Extrude1)(air in inner al tube-1), Shell-1(SolidBody 1(Cut-Extrude1))(air around upper al canister-1),

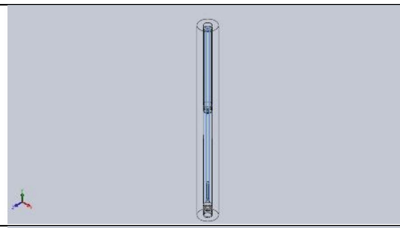
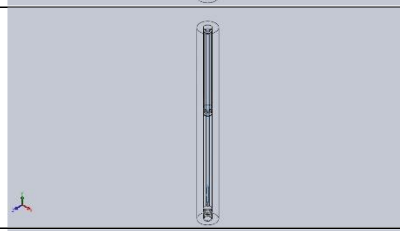
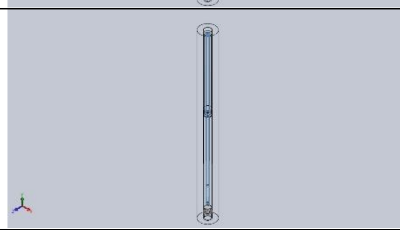
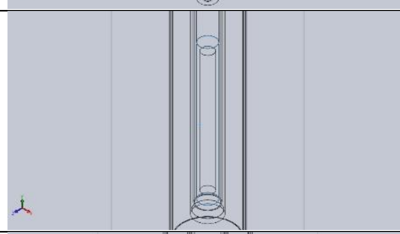
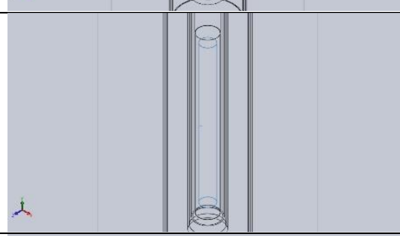
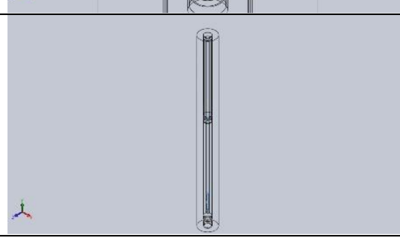
		Shell-2(SolidBody 1(Cut-Extrude1))(air around lower al canister-1), Shell-3(SolidBody 1(Cut-Extrude1))(air between pneumatic tubes-1), Shell-4(SolidBody 1(Cut-Extrude1))(air around quartz sample-1)
Curve Data:N/A		
	**Name:** boronPOWDER **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 0.047595 W/(m.K) **Specific heat:** 1020 J/(kg.K) **Mass density:** 1400 kg/m^3	SolidBody 1(Boss-Extrude2)(b-10 powder-1)
Curve Data:N/A		
	**Name:** B4C **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 28 W/(m.K) **Specific heat:** 950 J/(kg.K) **Mass density:** 1460 kg/m^3	SolidBody 1(Cut-Extrude1)(boron carbide-1)
Curve Data:N/A		
	**Name:** Glass **Model type:** Linear Elastic Isotropic **Default failure criterion:** Mohr-Coulomb Stress **Thermal conductivity:** 0.74976 W/(m.K) **Specific heat:** 834.61 J/(kg.K) **Mass density:** 2457.6 kg/m^3	SolidBody 1(Cut-Extrude1)(quartz sample-1), SolidBody 1(Boss-Extrude1[1])(sample inside quartz-1)
Curve Data:N/A		
	**Name:** Water **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 0.61 W/(m.K) **Specific heat:** 4200 J/(kg.K) **Mass density:** 1000 kg/m^3	SolidBody 1(Cut-Extrude2)(water-1)
Curve Data:N/A		

THERMAL LOADS

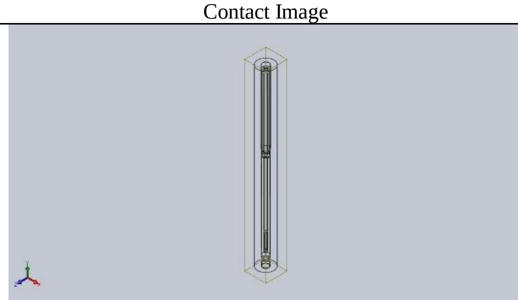
Load name	Load Image	Load Details
Heat Power: Air around Quartz		**Entities:** 2 component(s) **Heat Power Value:** 0.00070635 W
Heat Power: Air between Pneumatic Tubes		**Entities:** 1 component(s) **Heat Power Value:** 0.000228255 W
Heat Power: Quartz & Sample		**Entities:** 2 component(s) **Heat Power Value:** 0.0715266 W
Heat Power: WATER		**Entities:** 1 component(s) **Heat Power Value:** -574 W
Heat Power: 3-EL Al Tube		**Entities:** 1 component(s) **Heat Power Value:** 0.433606 W
Heat Power: B4C Al Canister		**Entities:** 1 component(s) **Heat Power Value:** 0.00478578 W

Heat Power: B4C Powder		**Entities:** 1 component(s) **Heat Power Value:** 0.97 W
Heat Power: B-10 Al Canister		**Entities:** 1 component(s) **Heat Power Value:** 0.367174 W
Heat Power: Cd Sleeve		**Entities:** 1 component(s) **Heat Power Value:** 591.52 W
Heat Power: Al Pneumatic Sleeve & Top Portion		**Entities:** 1 component(s) **Heat Power Value:** 0.158646 W
Heat Power: Enriched B-10 Powder		**Entities:** 1 face(s), 1 component(s) **Heat Power Value:** 223.56 W
Heat Power: Pneumatic System Al Tubing		**Entities:** 2 component(s) **Heat Power Value:** 0.17818 W
Heat Power: Al Spacer, Cd & Ag Disks		**Entities:** 1 component(s) **Heat Power Value:** 17.8595 W

Convection: Water		**Entities:** 5 face(s) **Convection Coefficient:** 100 W/(m^2.K) **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 338.15 Kelvin **Time variation:** Off
Radiation: S to A, Water		**Entities:** 3 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.96 **View Factor:** 0.5
Radiation: S to A, Al 3-EL Tube to Canisters, Spacer & Disks		**Entities:** 7 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5
Radiation: S to A, Various Al Media		**Entities:** 8 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5
Radiation: S to A, B-10 Powder		**Entities:** 3 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.82 **View Factor:** 0.5
Radiation: S to A, B4C Powder		**Entities:** 2 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.65 **View Factor:** 0.5
Radiation: S to A, Pneumatic Sleeve to Outer Pneumatic Tube		**Entities:** 2 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5

Radiation: S to A, Outer to Inner Pneumatic Tube		**Entities:** 4 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5
Radiation: S to A, Inner Pneumatic Tube to Air		**Entities:** 3 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5
Radiation: S to A, B4C Al canister to pneumatic system		**Entities:** 2 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5
Radiation: S to A, Quartz Sample to Sample		**Entities:** 1 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.75 **View Factor:** 0.5
Radiation: S to A, Sample		**Entities:** 1 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.03 **View Factor:** 0.5
Radiation: S to A, Air to Quartz		**Entities:** 3 face(s) **Radiation Type:** Surface to ambient **Ambient Temperature:** 338.15 Kelvin **Emissivity:** 0.02 **View Factor:** 0.5

CONTACT INFORMATION

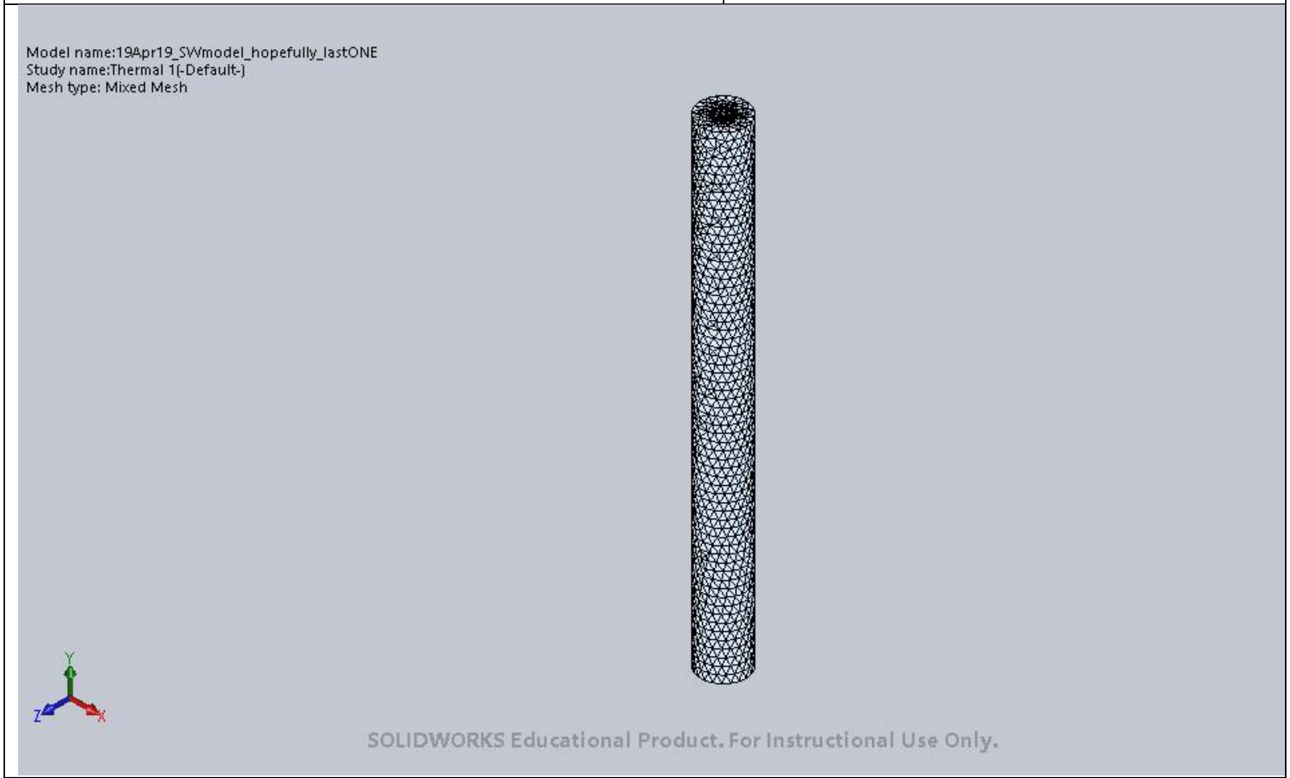
Contact	Contact Image	Contact Properties
Global Contact		**Type:** Bonded **Components:** 1 component(s) **Options:** Compatible mesh

MESH INFORMATION

Mesh type	Mixed Mesh
Mesher Used:	Curvature-based mesh
Jacobian points	4 Points
Jacobian check for shell	On
Maximum element size	1.92433 in
Minimum element size	0.275725 in
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	On

MESH INFORMATION - DETAILS

Total Nodes	522528
Total Elements	319865
Time to complete mesh(hh;mm;ss):	00:00:50
Computer name:	ME-AppD-VM11

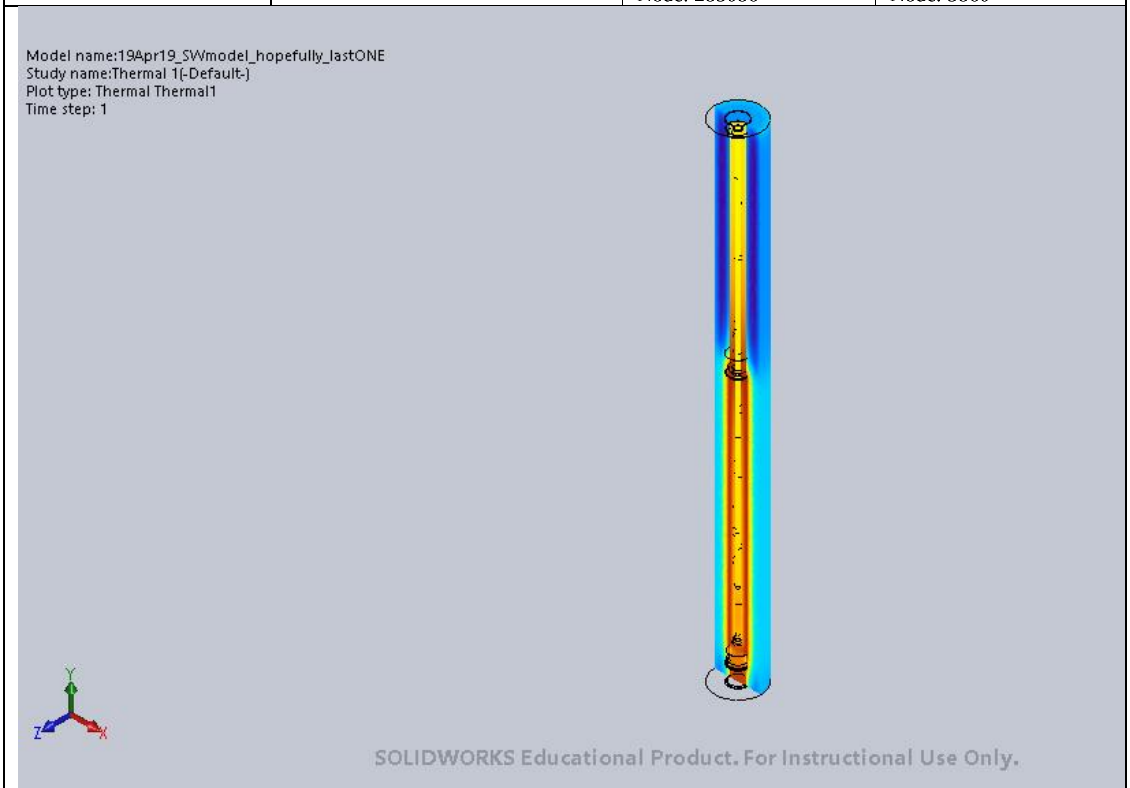


MESH CONTROL INFORMATION:

Mesh Control Name	Mesh Control Image	Mesh Control Details
Control-6		**Entities:** 2 Solid Body (s) **Units:** in **Size:** 0.627205 **Ratio:** 1.5

STUDY RESULTS

Name	Type	Min	Max
Thermal1	TEMP: Temperature	3.160e+02 Kelvin Node: 285086	3.944e+02 Kelvin Node: 5860



19Apr19_SWmodel_hopefully_lastONE-Thermal 1-Thermal-Thermal1

SolidWorks Flow Simulation Report

SYSTEM INFO

Product	Flow Simulation 2018 SP4.0. Build: 4264
Computer name	ME-AppD-VM07
User name	bad2284
Processors	Intel(R) Xeon(R) CPU E5-2683 v4 @ 2.10GHz

Memory	6143 MB / 134217727 MB
Operating system	Windows 10 (or higher) (Version 10.0.14393)
CAD version	SOLIDWORKS 2018 SP4.0
CPU speed	2100 MHz

GENERAL INFO

Model	Assem1forJUAN.SLDASM
Project name	Project(1)aalskalasd
Project path	\\austin.utexas.edu\disk\engrstu\me\bad2284\Desktop\4
Units system	SI (m-kg-s)
Analysis type	External (not exclude internal spaces)
Exclude cavities without flow conditions	On
Coordinate system	Global coordinate system
Reference axis	X

INPUT DATA

Global Mesh Settings

Automatic initial mesh: On

Result resolution level: 4

Advanced narrow channel refinement: Off

Refinement in solid region: Off

Geometry Resolution

Evaluation of minimum gap size: Automatic

Evaluation of minimum wall thickness: Automatic

Computational Domain

Size

X min	-0.095 m
X max	-0.021 m
Y min	-0.401 m
Y max	0.917 m
Z min	-0.012 m
Z max	0.065 m

Boundary Conditions

2D plane flow	None
At X min	Default
At X max	Default
At Y min	Default
At Y max	Default
At Z min	Default
At Z max	Default

Physical Features

Heat conduction in solids: On

Heat conduction in solids only: Off

Radiation: On

Time dependent: Off

Gravitational effects: On

Rotation: Off

Flow type: Laminar and turbulent

Cavitation: Off

High Mach number flow: Off

Free surface: Off

Default roughness: 5.0 micrometer

Gravitational Settings

X component	0 m/s^2
Y component	-9.81 m/s^2
Z component	0 m/s^2

Radiation

Default wall radiative surface: Blackbody wall

Radiation model: Ray Tracing

Environment radiation

Environment temperature	293.20 K
Spectrum	Blackbody

Ambient Conditions

Thermodynamic parameters	Static Pressure: 151325.00 Pa Temperature: 323.20 K
Velocity parameters	Velocity vector Velocity in X direction: 0 m/s Velocity in Y direction: 0.200 m/s Velocity in Z direction: 0 m/s
Solid parameters	Default material: Aluminum Initial solid temperature: 303.20 K Radiation Transparency: Opaque

Turbulence parameters	

Material Settings

Fluids

Water

Solids

Aluminum

Concrete blockyyy *(modified file of concrete given the B-10 powder properties)*

Concrete b4c *(modified file of concrete given the B4C properties)*

Default *(new file created, unfortunately not renamed, given the properties of cadmium)*

AIR

Quartz glass

Copper Tungsten (Cu10/W90) *(this is a sample material used to view heating inside quartz)*

Fluid Subdomains

Fluid Subdomain 1

Fluids	Water
Faces	Face<1>@LID12-1 Face<3>@Al tube for 3-EL-1 Face<2>@Al tube for 3-EL-1 Face<4>@LID12-1 Face<5>@LID12-1 Face<6>@Al tube for 3-EL-1 Face<8>@LID13-1 Face<7>@LID13-1 Face<9>@Al tube for 3-EL-1 Face<11>@LID13-1

	Face<10>@Al tube for 3-EL-1 Face<13>@Al tube for 3-EL-1 Face<12>@LID13-1
Coordinate system	Global coordinate system
Reference axis	X
Thermodynamic Parameters	Static Pressure: 151325.00 Pa Pressure potential: Off Temperature: 323.20 K
Velocity Parameters	Velocity in X direction: 0 m/s Velocity in Y direction: 0.200 m/s Velocity in Z direction: 0 m/s
Turbulence parameters type:	Turbulence intensity and length
Intensity	0.10 %
Length	4.763e-04 m
Flow type	Laminar and Turbulent
Cavitation	Off

Solid Materials

Aluminum Solid Material 1

Components	LID13-1@Assem1forJUAN Al cap-1@Assem1forJUAN Al-can lateral portion-1@Assem1forJUAN Al-can pneumatic sleeve and top portion-1@Assem1forJUAN inner pneumatic tube-1@Assem1forJUAN Al spacer with cd and silver disks-1@Assem1forJUAN

	al can for b4c-1@Assem1forJUAN Al tube for 3-EL-1@Assem1forJUAN LID12-1@Assem1forJUAN
Solid substance	Aluminum
Radiation Transparency	Opaque

Concrete blockyyy Solid Material 1

Components	b-10 powder-1@Assem1forJUAN
Solid substance	Concrete blockyyy
Radiation Transparency	Opaque

Concrete b4c Solid Material 1

Components	boron carbide-1@Assem1forJUAN
Solid substance	Concrete b4c
Radiation Transparency	Opaque

Default Solid Material 1

Components	Cd-sleeve-1@Assem1forJUAN
Solid substance	Default
Radiation Transparency	Opaque

AIR Solid Material 1

Components	air between pneumatic tubes-1@Assem1forJUAN air around quartz sample-1@Assem1forJUAN air around upper al canister-1@Assem1forJUAN air around lower al canister-1@Assem1forJUAN

	air in inner al tube-1@Assem1forJUAN
Solid substance	AIR
Radiation Transparency	Opaque

Quartz glass Solid Material 1

Components	quartz sample-1@Assem1forJUAN
Solid substance	Quartz glass
Radiation Transparency	Opaque

Copper Tungsten (Cu10/W90) Solid Material 1

Components	sample inside quartz-1@Assem1forJUAN
Solid substance	Copper Tungsten (Cu10/W90)
Radiation Transparency	Opaque

Boundary Conditions

Real Wall 1

Type	Real wall
Faces	Al tube for 3-EL-1/Cut-Extrude2//Face Al tube for 3-EL-1/Cut-Extrude2//Face Al tube for 3-EL-1/Cut-Extrude2//Face Al tube for 3-EL-1/Cut-Extrude2//Face Al tube for 3-EL-1/Cut-Extrude2//Face
Coordinate system	Global coordinate system
Reference axis	X
Roughness	5.0 micrometer
Heat transfer coefficient	5000.000 W/m^2/K

Dynamic boundary layer thickness	0 m

Heat Volume Sources

VS Heat Generation Rate 1

Components	Al cap-1@Assem1forJUAN b-10 powder-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	224.000 W

VS Heat Generation Rate 2

Components	Cd-sleeve-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	592.000 W

VS Heat Generation Rate 3

Components	Al spacer with cd and silver disks-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	17.000 W

VS Heat Generation Rate 4

Components	Al tube for 3-EL-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	0.430 W

VS Heat Generation Rate 5

Components	Al-can pneumatic sleeve and top portion-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	0.170 W

VS Heat Generation Rate 6

Components	pneumatic system-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	0.160 W

VS Heat Generation Rate 7

Components	air between pneumatic tubes-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate

Heat generation rate	2.300e-04 W

VS Heat Generation Rate 8

Components	inner pneumatic tube-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	0.180 W

VS Heat Generation Rate 9

Components	air around quartz sample-1@Assem1forJUAN air in inner al tube-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	7.000e-04 W

VS Heat Generation Rate 10

Components	quartz sample-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Source type	Heat Generation Rate
Heat generation rate	0.070 W

LOCAL INITIAL CONDITIONS

Initial Condition 1

Components	Al cap-1@Assem1forJUAN LID13-1@Assem1forJUAN pneumatic system-1@Assem1forJUAN b-10 powder-1@Assem1forJUAN Al-can lateral portion-1@Assem1forJUAN air between pneumatic tubes-1@Assem1forJUAN Al-can pneumatic sleeve and top portion-1@Assem1forJUAN boron carbide-1@Assem1forJUAN air around quartz sample-1@Assem1forJUAN inner pneumatic tube-1@Assem1forJUAN al can for b4c-1@Assem1forJUAN Al spacer with cd and silver disks-1@Assem1forJUAN quartz sample-1@Assem1forJUAN air around lower al canister-1@Assem1forJUAN air around upper al canister-1@Assem1forJUAN Al tube for 3-EL-1@Assem1forJUAN Cd-sleeve-1@Assem1forJUAN air in inner al tube-1@Assem1forJUAN sample inside quartz-1@Assem1forJUAN LID12-1@Assem1forJUAN
Coordinate system	Global coordinate system
Reference axis	X
Temperature of solid bodies	303.20 K

RADIATIVE SURFACES

Radiative Surface 1

Faces	Al tube for 3-EL-1@Assem1forJUAN Al spacer with cd and silver disks-1@Assem1forJUAN inner pneumatic tube-1@Assem1forJUAN LID12-1@Assem1forJUAN Al-can pneumatic sleeve and top portion-1@Assem1forJUAN Al-can lateral portion-1@Assem1forJUAN al can for b4c-1@Assem1forJUAN Al cap-1@Assem1forJUAN LID13-1@Assem1forJUAN pneumatic system-1@Assem1forJUAN
Type	Aluminum, rough

Radiative Surface 2

Faces	air between pneumatic tubes-1@Assem1forJUAN air around quartz sample-1@Assem1forJUAN air around lower al canister-1@Assem1forJUAN air around upper al canister-1@Assem1forJUAN air in inner al tube-1@Assem1forJUAN
Type	AIR

CALCULATION CONTROL OPTIONS

Finish Conditions

Finish Conditions	If one is satisfied

Maximum travels	4.000
Goals convergence	Analysis interval: 0.500

Solver Refinement

Refinement: Disabled

Results Saving

Save before refinement	On

Advanced Control Options

Flow Freezing

Flow freezing strategy	Disabled

View factor resolution level: 3

RESULTS

General Info

Run at: ME-AppD-VM07

Number of cores: 4

Iterations: 104

CPU time: 129 s

Log

Mesh generation started 0	18:19:08 , Apr 27
Mesh generation normally finished 0	18:19:29 , Apr 27
Preparing data for calculation 0	18:29:46 , Apr 27
Calculation started 0	18:29:55 , Apr 27
Calculation has converged since the following criteria are satisfied: 118	18:32:06 , Apr 27

Goals are converged 118	
Calculation finished 118	18:32:10 , Apr 27

Calculation Mesh

Basic Mesh Dimensions

Number of cells in X	12
Number of cells in Y	194
Number of cells in Z	12

Number Of Cells

Cells	71308
Fluid cells	26112
Solid cells	45196
Irregular cells	0
Trimmed cells	0

Maximum refinement level: 1

Goals

Name	Unit	Value	Progress	Criteria	Delta	Use in convergence

Min/Max Table

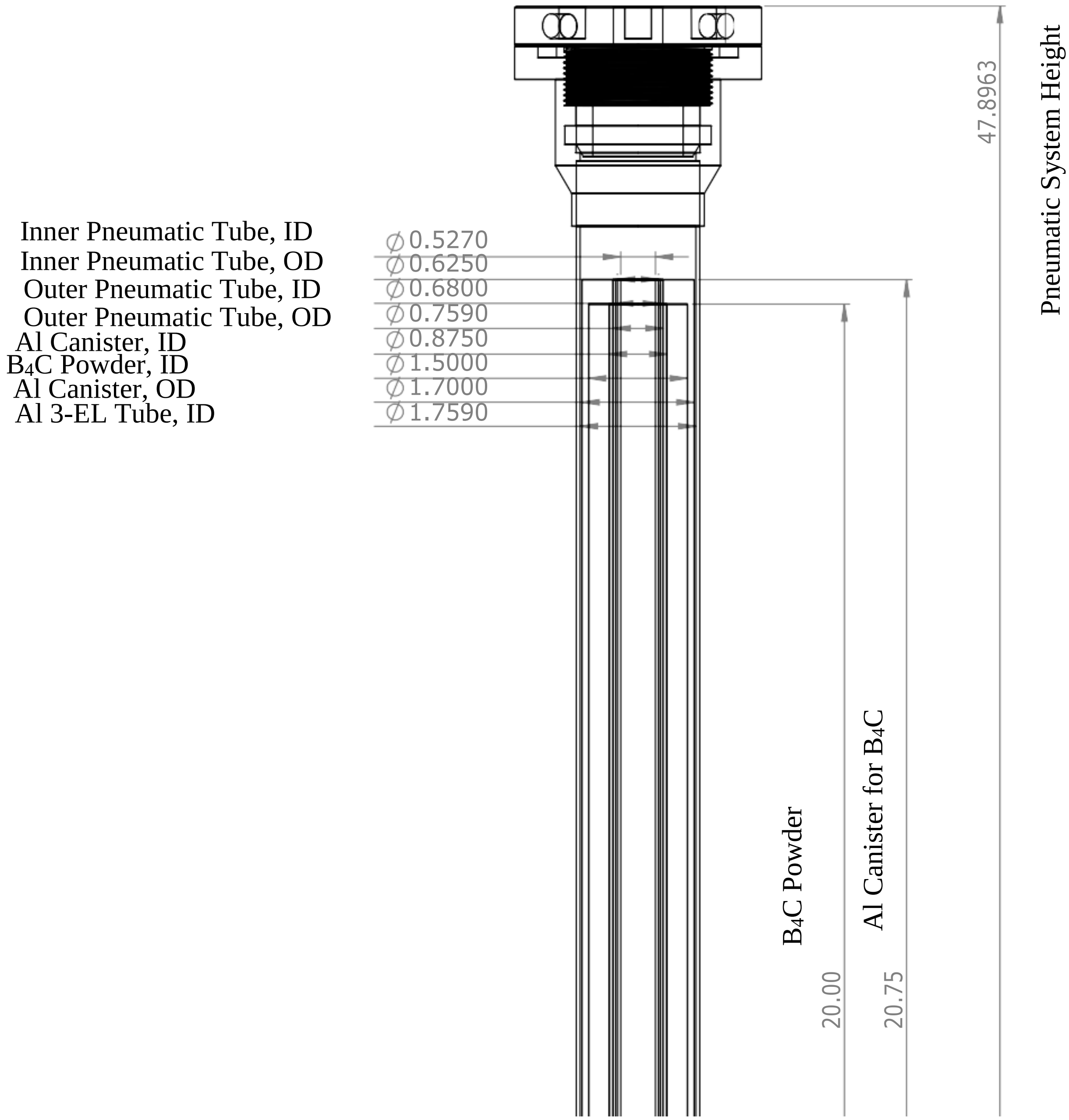
Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	984.21	989.29
Density (Solid) [kg/m^3]	1.23	17170.00
Pressure [Pa]	142443.76	155216.26

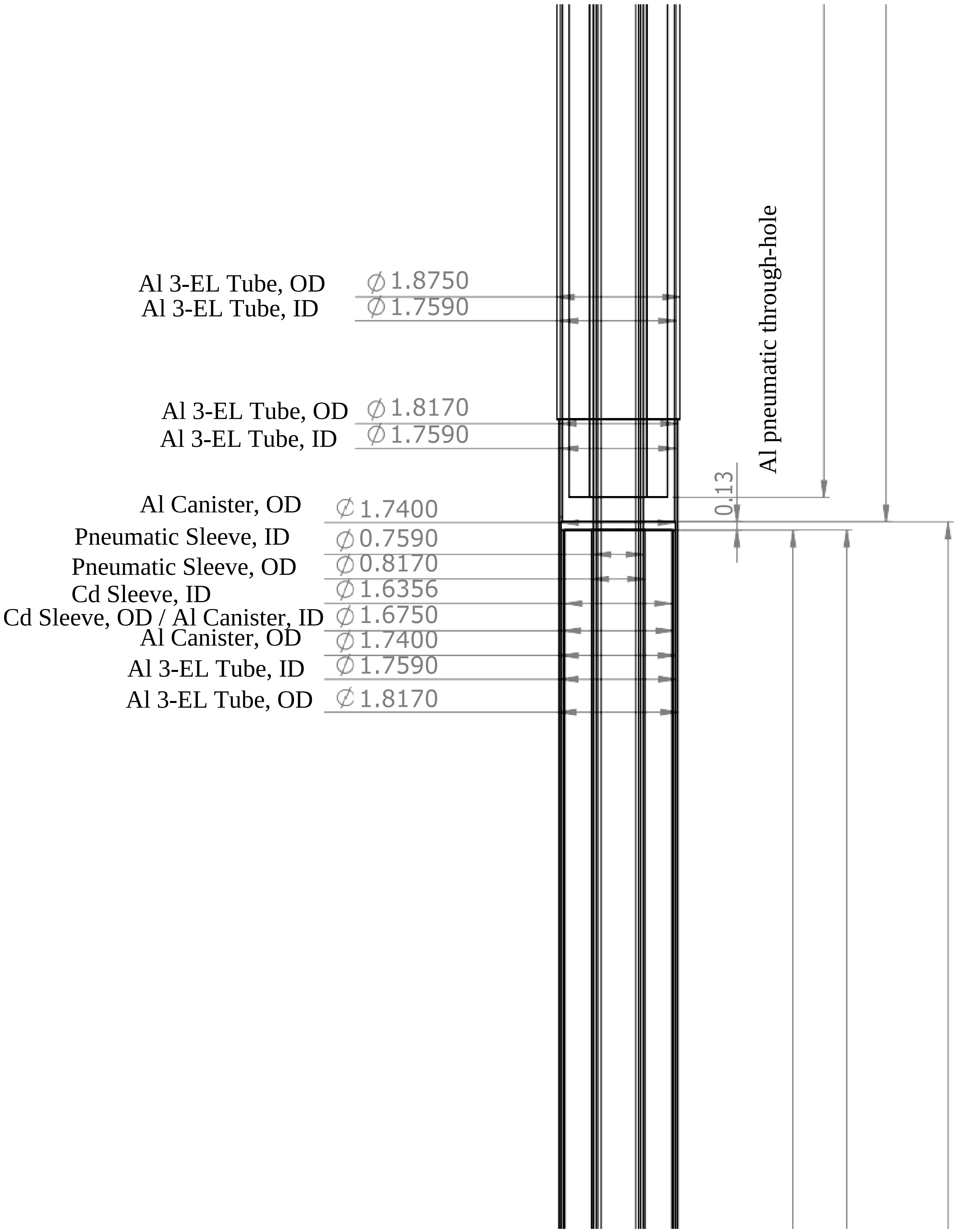
Temperature [K]	318.70	427.30
Temperature (Fluid) [K]	318.70	330.47
Temperature (Solid) [K]	323.31	427.30
Velocity [m/s]	0	0.251
Velocity (X) [m/s]	-0.200	0.201
Velocity (Y) [m/s]	-0.086	0.219
Velocity (Z) [m/s]	-0.203	0.201
Aspect Ratio CV [ ]	1.0322352	2033.8984438
Channel Height [m]	3.333e-07	0.763
Domain Index (Fluid) [ ]	0	2
Gap Size [m]	0.002	0.050
Wall Distance [m]	0.001	0.054
Axial Velocity [m/s]	-0.203	0.201
Circumferential Velocity [m/s]	-0.211	0.192
Lambda2-Criterion [1/s^2]	-322.73	120.73
Normal Velocity [m/s]	-0.251	0.251
Radial Velocity [m/s]	-0.219	0.201
Tangential Velocity [m/s]	0	0.251
Velocity RRF [m/s]	0	0.251
Velocity RRF (X) [m/s]	-0.200	0.201
Velocity RRF (Y) [m/s]	-0.086	0.219
Velocity RRF (Z) [m/s]	-0.203	0.201
Vorticity [1/s]	0.04	45.68
Vorticity (X) [1/s]	-39.42	38.14
Vorticity (Y) [1/s]	-15.58	6.82
Vorticity (Z) [1/s]	-38.72	38.41

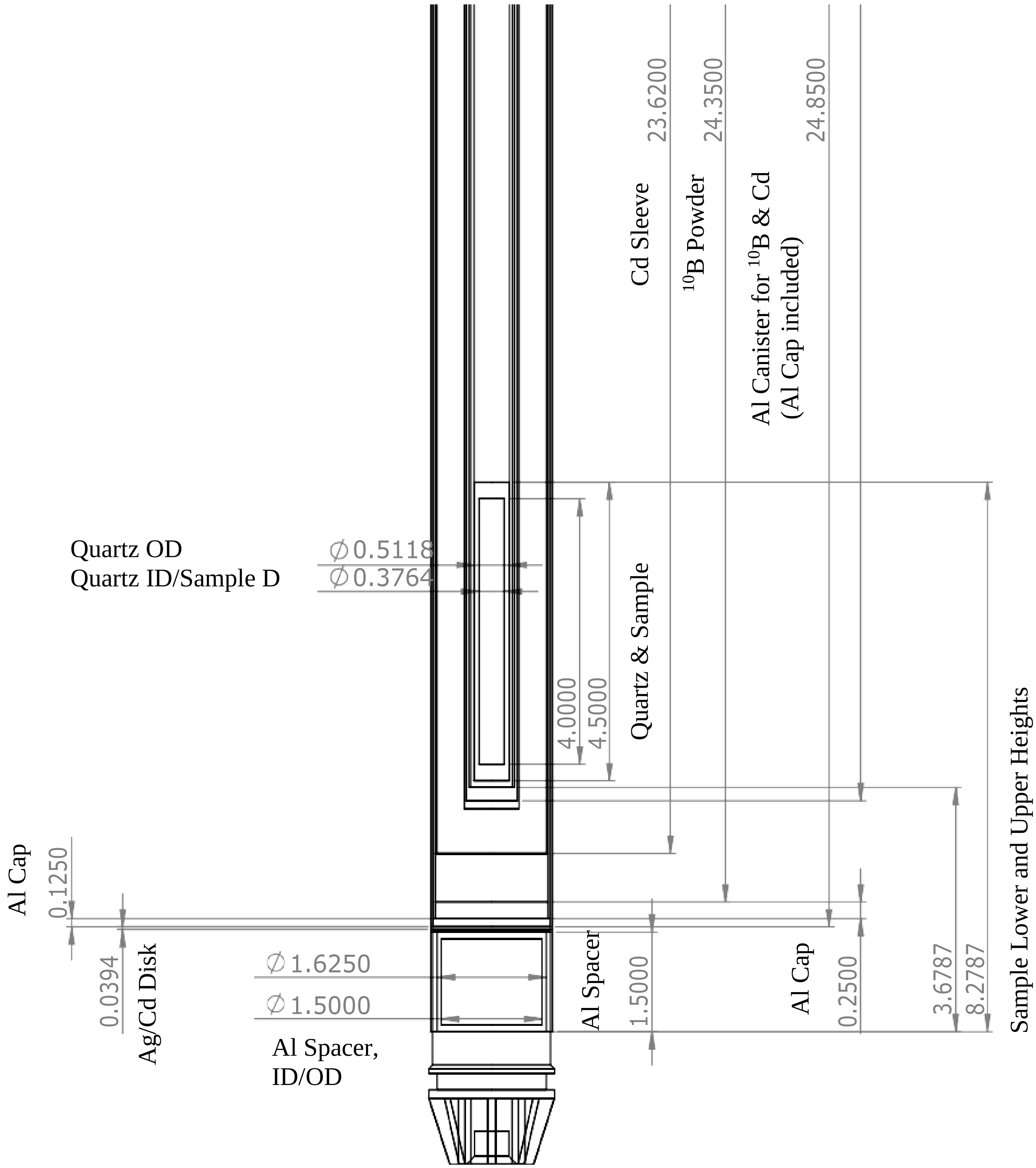
Dynamic Pressure [Pa]	0	31.06
Friction Coefficient [ ]	0	65.9272
Reference Density [kg/m^3]	984.21	989.29
Reference Pressure [Pa]	151325.00	151325.00
Reference Velocity [m/s]	0	0.214
Relative Pressure [Pa]	-8881.24	3891.26
Shear Stress [Pa]	0	1.35
Shear Stress (X) [Pa]	-1.26	1.28
Shear Stress (Y) [Pa]	-0.61	0.83
Shear Stress (Z) [Pa]	-1.25	1.27
Total Pressure [Pa]	142446.51	155235.63
Dynamic Viscosity [Pa*s]	0.0005	0.0006
Fluid Thermal Conductivity [W/(m*K)]	0.6380	0.6515
Prandtl Number [ ]	3.1242637	3.8700346
Specific Heat (Cp) [J/(kg*K)]	4180.5	4184.1
Absolute Total Enthalpy [J/kg]	1343438.012	1392649.558
Adiabatic Fluid Temperature [K]	318.70	330.40
Bottleneck Number [ ]	5.9630290e-18	1.0000000
Heat Flux [W/m^2]	0.044	3733950.299
Heat Transfer Coefficient [W/m^2/K]	0.257	73745.137
Heat Transfer Coefficient (Adiabatic Temperature) [W/m^2/K]	0.010	1.478e+07
Overheat above Melting Temperature [K]	-9676.553	-506.738

Reference Fluid Temperature [K]	323.20	323.20
ShortCut Number [ ]	2.2084783e-17	1.0000000
Stanton Number [ ]	-7.8649	31.4925
Surface Heat Flux [W/m^2]	-202584.134	202584.134
Surface Heat Flux (Conductive) [W/m^2]	-202584.134	202584.134
Surface Heat Flux (Convective) [W/m^2]	-11389.511	25366.903
Wall Temperature [K]	323.31	330.47
Turbulence Intensity [%]	0.10	1000.00
Turbulence Length [m]	6.400e-06	0.002
Turbulent Dissipation [W/kg]	2.94e-12	0.02
Turbulent Energy [J/kg]	5.333e-10	0.002
Turbulent Time [s]	0.023	181.540
Turbulent Viscosity [Pa*s]	7.4711e-10	0.0356
Boundary Layer Thickness [m]	7.743e-05	0.058
Boundary Layer Thickness (Thermal) [m]	7.031e-05	0.058
Boundary Layer Type [ ]	0	1.0000000
Thin Channel Mode [ ]	0	1
Acoustic Power [W/m^3]	1.419e-48	1.591e-22
Acoustic Power Level [dB]	0	0

SolidWorks Schematic of the 3-EL




Al 3-EL Tube, OD
⌀1.8750
Al 3-EL Tube, ID
⌀1.7590
Al 3-EL Tube, OD
⌀1.8170
Al 3-EL Tube, ID
⌀1.7590
Al pneumatic through-hole
0.13
Al Canister, OD
⌀1.7400
Pneumatic Sleeve, ID
⌀0.7590
Pneumatic Sleeve, OD
⌀0.8170
Cd Sleeve, ID
⌀1.6356
Cd Sleeve, OD / Al Canister, ID
⌀1.6750
Al Canister, OD
⌀1.7400
Al 3-EL Tube, ID
⌀1.7590
Al 3-EL Tube, OD
⌀1.8170


Cd Sleeve
23.6200
^{10}B Powder
24.3500
Al Canister for ^{10}B & Cd
(Al Cap included)
24.8500
Quartz OD
Quartz ID/Sample D
∅0.5118
∅0.3764
4.0000
4.5000
Quartz & Sample
Sample Lower and Upper Heights
Al Cap
0.1250
0.0394
Ag/Cd Disk
∅1.6250
∅1.5000
Al Spacer,
ID/OD
Al Spacer
1.5000
Al Cap
0.2500
3.6787
8.2787

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VITA

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